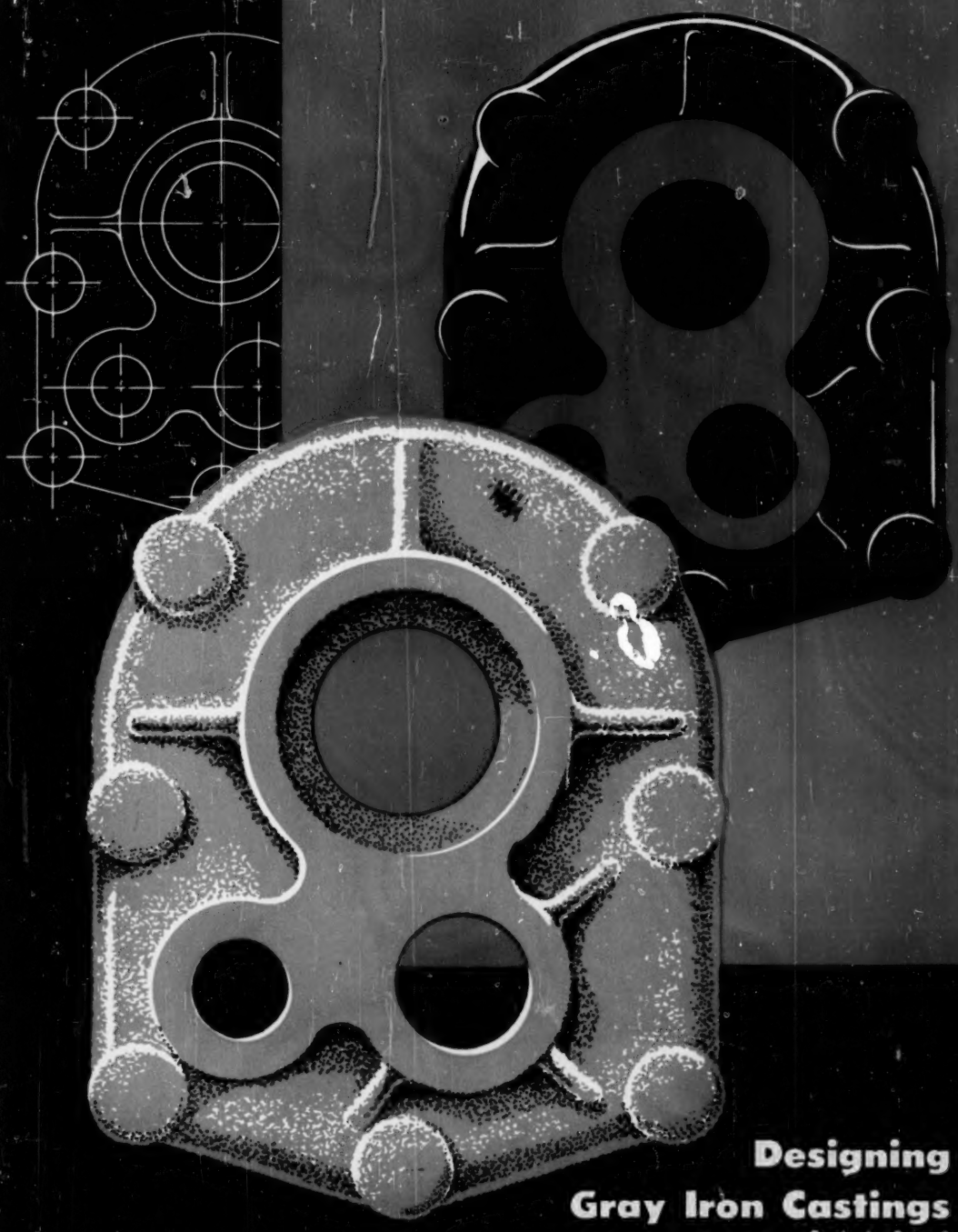
JANUARY 10, 1957
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Designing Gray Iron Castings

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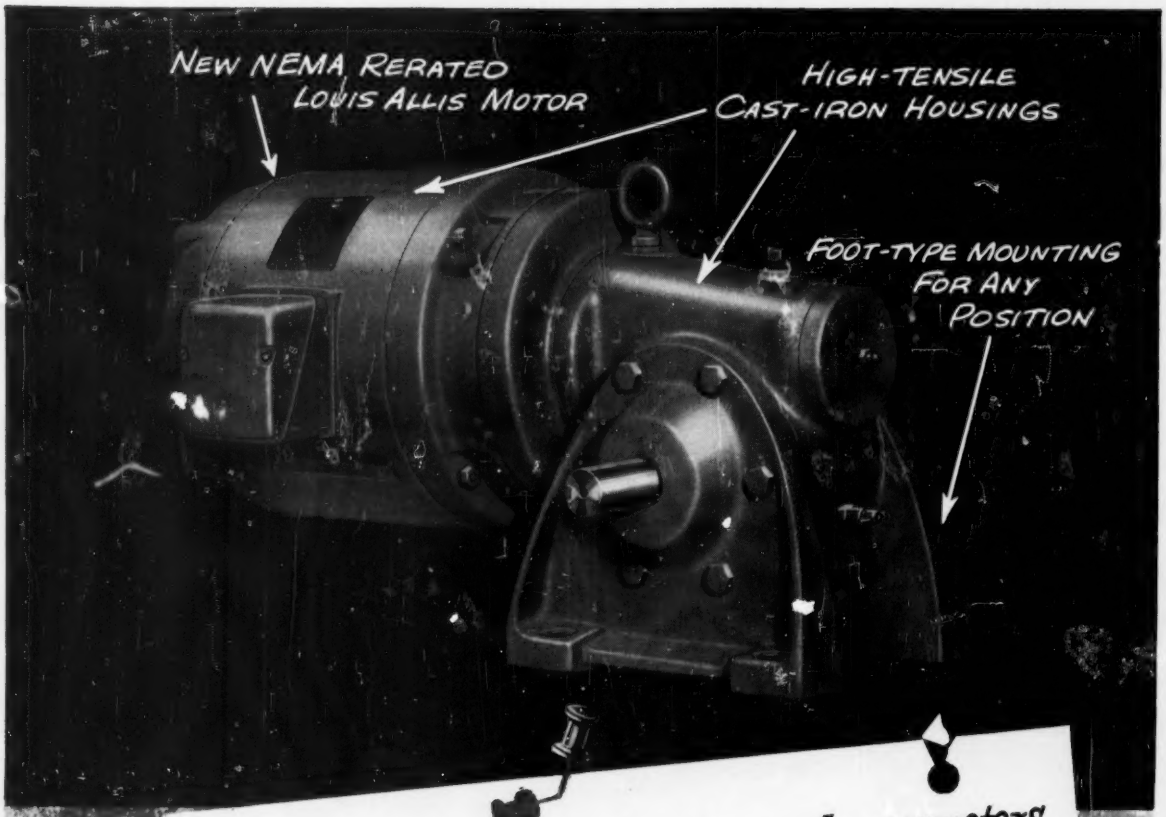


Louis Allis announces its L.A. line of right-angle gearmotors

Now available with new NEMA rerated L.A. motors for all applications — in sizes from 1 to 30 hp

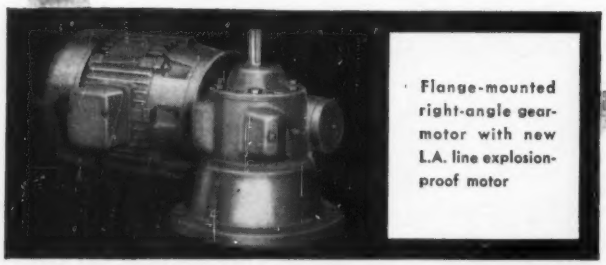
Before we go into the many design features of this compact gearmotor, let's take a look at a few other advantages:

First of all, you can get either foot- or flange-mounted units. Secondly, you can have any motor enclosure you want. And finally, you can have any electrical or mechanical modification needed for any specific application.

In other words, here's a line of gearmotors ruggedly designed, versatile and efficient—to give you a sound answer to your right-angle gearmotor drive problems. Here's why:

- Both gear and motor housings are made of high-tensile cast iron to provide maximum strength, rigidity, and compactness.
- The worm, carefully machined from hardened alloy steel, is ground to close tolerances to give greater efficiency and longer life.
- The worm gear is cut from a high grade of wear-resistant alloy bronze.
- A double-row angular contact bearing and a ball bearing provide for radial and thrust loads on the worm shaft.
- The output shaft is mounted in tapered roller bearings for maximum load-carrying capacity.
- Ample oil-bath lubrication assures longer life and minimum maintenance.
- Special oil seals on all shafts keep the oil in--dirt out and permit any mounting arrangement.

Here's a line of right-angle gearmotors that's very easy to apply. Standard speed range from 7-1/2 to 300 rpm--special speeds also are available.



Flange-mounted right-angle gearmotor with new L.A. line explosion-proof motor

GM-103

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN

Circle 401 on page 19

ANNOUNCING!

Ross Starline Air Control Valves

Send For FREE FILE

of new valve data

A new valve series to help you solve thousands of design problems, use air more effectively, get the benefit of parts interchangeability! It's the ROSS Starline Series. Over 500 valve models. In-line or base mounted, solenoid or air activated. ¼" through 1¼" sizes. Both standard and JIC construction. Write for free data file!

Ross

A galaxy of new air-control stars are coming your way from

OPERATING VALVE CO.

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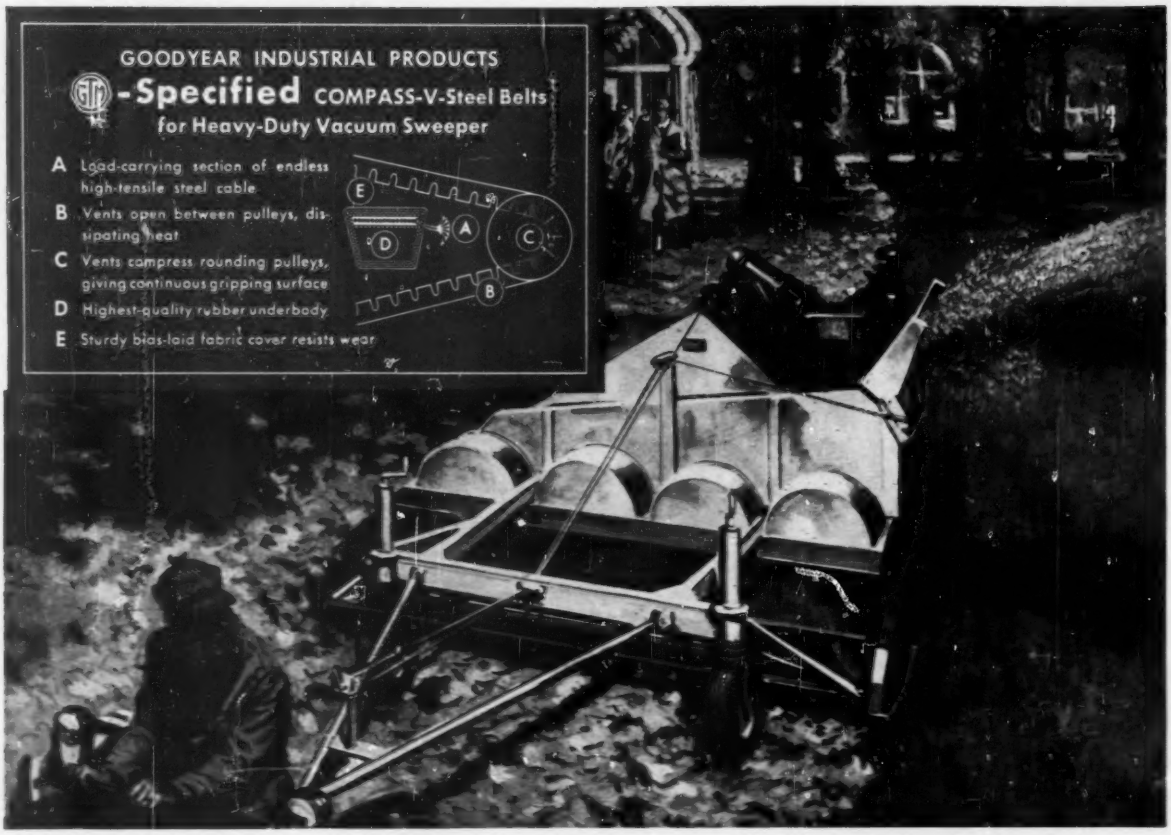
Circle 404 on page 19



Now—a Vacuum Cleaner for all outdoors!

It's 1952. You're a manufacturer of heavy-duty vacuum sweepers and you've got a problem.

Out in your plant is a big, new tractor-drawn unit that will remove and mulch leaves and litter from as many as 25 to 30 acres per day. That is, provided you can find a V-belt to handle the 25-h.p. 2000-r.p.m. drive.

On this drive, you have one four-groove drive pulley and four separate driven pulleys. To operate efficiently, the belts must be perfectly matched and must stay that way. So far no belt tried has turned the trick.

Finally, you ask the G.T.M.—Goodyear Technical Man—for help. He studies the drive and recommends COMPASS-V-Steel belts muscled with airplane-type steel cables. You put them on the drive and the machine on the market.

Today, you're still using the G.T.M.'s belts and in almost *four years* haven't had a *single complaint*. What's more, the G.T.M. is your No. 1 Counselor on any industrial rubber problem. You contact him often through your Goodyear Distributor or Goodyear, Industrial Products Division, Akron 16, Ohio.

COMPASS-V-STEEL BELTS by

GOODYEAR

THE GREATEST NAME IN RUBBER

Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

January 10, 1957
Volume 29—No. 1

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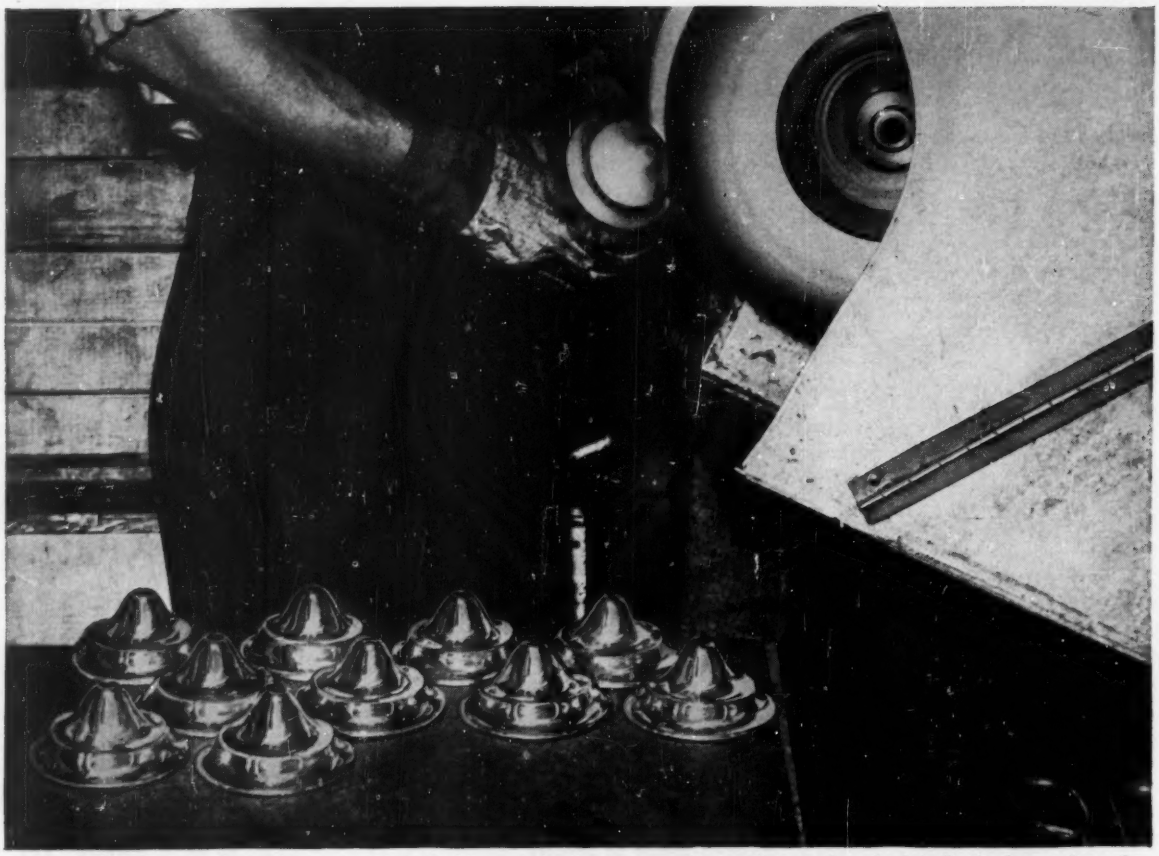
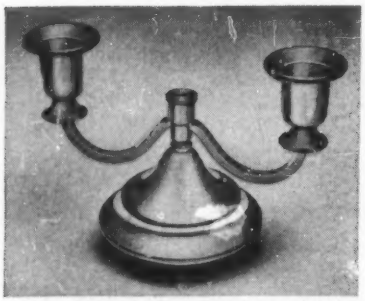


THE BASE of a Huntercraft Candelabra Model 8008 (shown below) requires, with Formbrite, only a finish buff. The base is formed in two drawing operations. The deeper drawn candle cups, also of Formbrite, need only a light cutting with Tripoli and a finish buff.

It's easy to get a jeweler's finish with Formbrite



HUNTERCRAFT Table or Wall Candelabra Model 8008, one of 30 fine brassware items in the line of Huntercraft Originals.

"Formbrite cut polishing cost and time dramatically—was a major factor in keeping our small business alive . . . and growing," says Ralph E. Hunter of Huntercraft.

THE production of Huntercraft Originals—now a nationally distributed line of fine brassware—has grown from a basement hobby to a thriving new business in less than 5 years.

The Hunter Machine Service Company of Racine, Wisc., began manufacturing Huntercraft Originals on a commercial scale in 1951, using ordinary soft forming brass. To get the gleaming jeweler's finish required, polishing time and costs were high. In fact, they were so high that the young company found it impossible to bring their prices into line with competition.

In 1953, they tried Formbrite®, Anaconda's superfine-grain drawing brass. The polishing bottleneck was broken and production soared – unit costs went way down. According to Ralph E. Hunter, owner and president of Hunter Machine Service Co., Formbrite was a major factor in keeping the company alive and enabling it to go on to become a stable, growing business. The finish obtained so easily on Formbrite, he adds, is superior to that achieved on ordinary drawing brass.

Formbrite is a premium product at a nonpremium price. Find out for yourself how its superfine-grain, excellent drawing properties, strength, and scratch-resistance can help you make a better product at lower cost. Write for Publication B-39. Better yet, ask for a sample or a trial batch. Address: The American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5672

Formbrite SUPERFINE-GRAIN DRAWING BRASS

an ANACONDA® product

made by The American Brass Company

Circle 406 on page 19

Engineering News Roundup

Future Car Styles to Depend On Engines, Air Conditioning

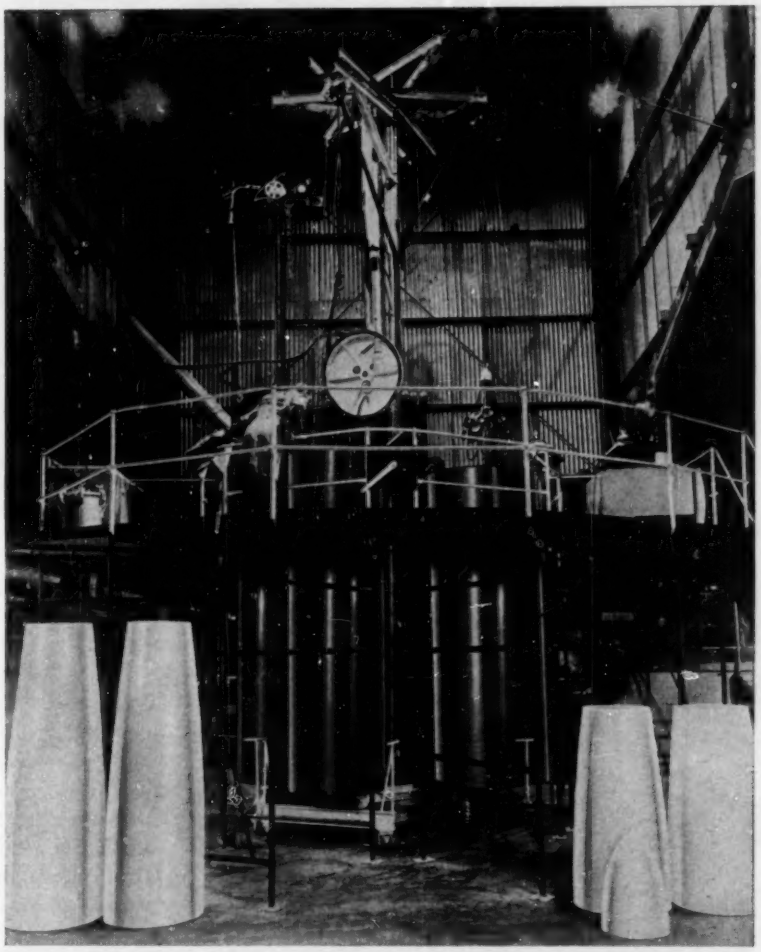
But Customer's Purse and Person Will Be Decisive

NEW YORK, N. Y.—The shapes of automobiles to come will be quite different than current models when new developments in power are adopted by the auto industry. Future cars will be safer than present models and still more comfortable, but the final arbiter of style will continue to be the buying public itself. These were recent predictions and observations by the chief designers for the five top car manufacturers. The stylists participated in a panel discussion on the trends in automobile styling, arranged by the American Society of Industrial Designers.

One panelist, William Schmidt, vice president and director of styling of the Studebaker-Packard Corp., predicted that eventually a new rail-type highway system with a rail either overhead or on the highway itself would be introduced for greater safety. Over 75 million cars will be on the road by 1970, and crowding will be an increasing problem. The rail system could be the answer. Power could be supplied by a source other than the car's own power plant and would allow cars traveling off the highway to run on a compact storage battery. "Developments of this type," Mr. Schmidt said, "could radically affect the appearance of the car of the future."

Robert H. Maguire, chief of advanced styling of Ford Motor Co., said only the passenger and his comfort, plus necessary road clearance, will limit the lowness of future automobiles. The low cars will foster the invention of methods of entry and new seating which will strongly affect design forms. Another important feature in the mass car of the future, he said, would be air conditioning. This will allow fixed curved side glass, new roof contours, and new interior door and roof treatment.

Carl Reynolds, assistant director of styling of Chrysler Corp., emphasized the designer's role in

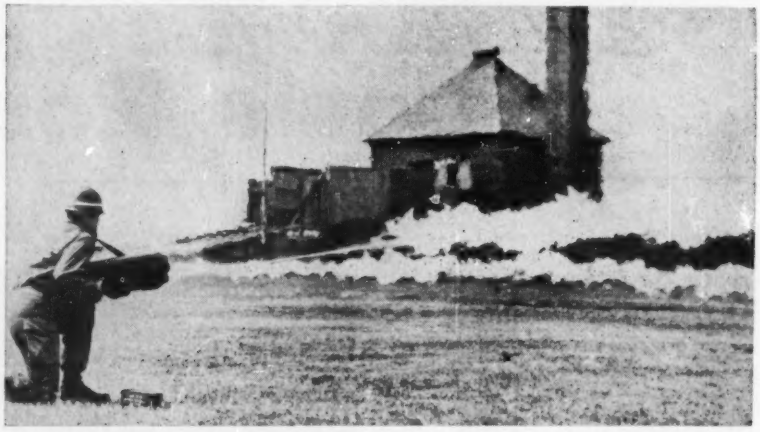


PLASTIC GOES 'ROUND AND 'ROUND to form cylindrical shapes at low mass cost in this new machine, the only one of its kind, installed at Pastushin Aviation Corp. Operating like a carousel, the machine spins resin and chopped glass fibers into six molds simultaneously. A single operator can produce parts as large as 10 ft long, 44 in. diam, one every 10 minutes. Exceptional strength, uniformity and tolerances in the products are credited to centrifugal action. The "carousel" can also form parts out-of-round as much as 20 per cent and mold integral stiffeners. Typical products are jet engine parts, mine sweeper floats, aircraft fuel tanks and missile bodies.

combining practicality with beauty. He predicted that fins now used on Chrysler cars would continue to play a role in future automotive design since it already has been proved in wind tunnel tests that fins do contribute to a car's stability.

William L. Mitchell, director of styling, General Motors Corp., told the panel audience to look to the consumer for the key to what cars are going to be like tomorrow. He said that General Motors is against drastic changes from year to year and that personality would continue to be stressed in future GM models.

Edmund E. Anderson, director of automotive styling at American Motors Corp., said that three major types of cars would dominate tomorrow's market: The personal car, the compact car, and the large, long-distance limousine. Mr. Anderson said that prime considerations in designing a car are: to express its purpose, to make it distinctive, to make the public accept the design, and to meet the intended market price.



SINGLE-SHOT FLAME THROWER, developed for Army Chemical Corps by Aerojet-General Corp., weighs 26½ lb and holds 2 gallons of fuel. Relatively light compared to 72-lb multiple-shot type, the new weapon can be jumped with a paratrooper. In defensive situations it can be fitted with a remote-firing device or used as a booby-trap.

Aircraft Glass Will Have Rubber Layer to Take Heat

TOLEDO, O.—Transparent rubber is being tested by the Air Force as a way to beat the heat on airplane windshields.

The rubber will be used as an interlayer in windshield glass of new supersonic airplanes. With this new material, it is expected that windshields will be able to withstand twice as much heat as formerly from air friction at high speeds. The heat can reach such intensity that the flexible, transparent plastic now used as a windshield interlayer softens and loses strength. When its strength is gone, the interlayer is unable to prevent the glass from shattering if cracked.

The new rubber interlayer is being developed for the Air Research and Development Command, Wright Air Development Center, by Dow Corning Corp. It retains adequate strength up to 350 F as compared to the limit of 180 F for present plastic interlayers.

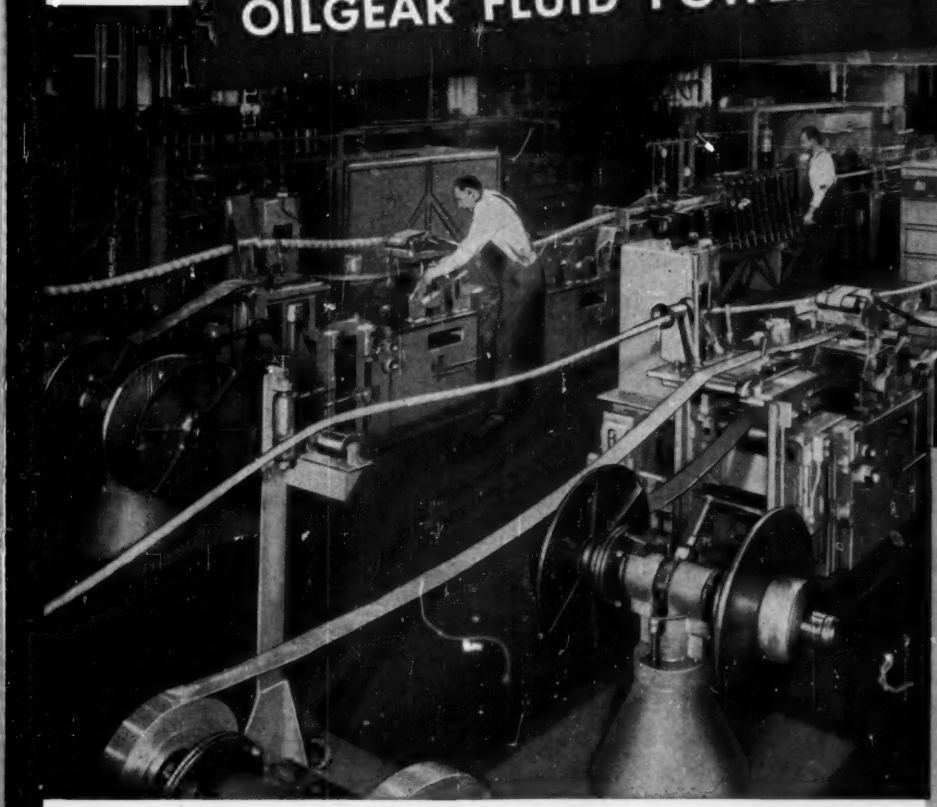
At the other end of the temperature scale, the new interlayer retains its shatter resistance properties down to −65 F. The present

PERFORMANCE PROBE for Bomarc guided missle systems is this 17-ft nose added to a conventional Air Force B-57 Canberra bomber. Under a contract with Boeing, Temco Aircraft Corp. added the nose to convert the bomber to a flying test bed for the missile components. Lengthening the nose necessitated addition of equipment and ballast to the rear of the plane, and strengthening of the original nose structure. Separate hydraulic and electrical systems were added for the missile guidance system, and ammonia and nitrogen tanks were added for cooling and pressurizing the missile nose.

Front Cover

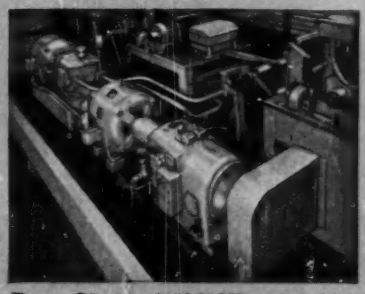
Progression of a casting design from the original engineering drawing, through a wood pattern to the final cast part is the theme of George Farnsworth's cover. Featured article is "Designing Gray Iron Castings" by Arthur Scharf and Charles Walton on Page 104.

Here, Western Electric Employs OILGEAR FLUID POWER DRIVES

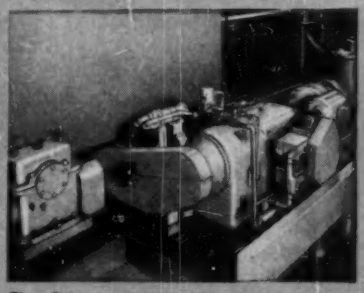


"Stalpeth" machines add moisture barriers to telephone cable

These machines receive cable core, wrap it in aluminum and steel, solder the seam and coil it on reels. Oilgear *ANY-SPEED* Fluid Power Drives are an easy and economical means of synchronizing many machine units without a long lineshaft.



These Oilgear *ANY-SPEED* units drive the aluminum and steel corrugator units in perfect unison with the governing capstan unit.



The Oilgear *ANY-SPEED* capstan drive. Not shown here is another Oilgear unit driving the cable winding reels.

Solving the problem of close synchronization of driven members

As machines become more and more complex, combining more and more functions into a single unit, the problem of driving these machines successfully becomes more difficult.

This problem confronted Western Electric Company engineers in designing what they call their "Stalpeth" machines, two of which are shown above. These machines combine corrugating of steel and aluminum strips, forming them around the cable core, soldering the seam and then winding the assembly on reels at the far end. All of the members of the machine must be synchronized to the speed of the capstan unit. Going by their experience with other somewhat similar machines, Western Electric engineers again turned to Oilgear *"Any-Speed"* Fluid Power Drives, to solve what is really a complex problem ordinarily. Oilgear units provided an easy and economical means of synchronizing many machine components.

Oilgear *Any-Speed* Fluid Power Drives and transmissions *do* offer many machine design advantages including ease of control and synchronization of driven members, steplessly variable speed, fundamentally simple circuits, and long, trouble-free life. Write for Oilgear drive bulletins. THE OILGEAR COMPANY, 1568 W. Pierce St., Milwaukee 4, Wisconsin.

OILGEAR
Fluid Power

PIONEERS . . . NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

interlayer becomes brittle and loses shatter resistance at that temperature.

The rubber interlayer is a bit cloudier than the plastic material, and up to 60 F has less shatter resistance. However, strength of the plastic interlayer falls off so sharply that at 200 F the rubber interlayer is already more than twice as effective.

The new material has a silicone base and is cured at high temperatures during lamination by processes that turn it into a tough, transparent rubber material.

Here's an engineer who knows what he's doing even though he can't see it. Ted Glasser, blind since he was 8, uses braille-type aids to program digital computers. His "seeing-eyes" are behind the cold nose at his elbow.

Despite Blindness, Engineer Programs Computers

PASADENA, CALIF.—An exceptionally fine example of an engineer who has overcome obstacles to win professional status and recognition is Ted Glasser, Phi Beta Kappa mathematician heading a computer design group at the Electro-Data Div. of Burroughs Corp. Ted has been blind since he was 8 years old. On the job, he works out the arrangements of electronic "building blocks" with which digital computers perform their varied assignments. Ted sets up equations as rapidly as fully sighted people using a blackboard and chalk.

Although his sight failed completely in grammar school, Ted not only graduated on schedule but scholastically at the head of his class. He went on to graduate from Dartmouth College in 1951 with Phi Beta Kappa honors and the Thayer Mathematics Prize. He told how he did it in a research thesis entitled "The Blind Student in College."

Ted relies on a braille typewriter and a special embossing tool with which he writes and draws on plastic sheets. He sets up equations on a pegboard with metal slugs which bear raised symbols on both ends. Other aids, equally indispensable, are his wife, Ann, and his seeing-eye dog, Asta.

Machine design competition offering $25,000 in 26 awards has been announced by the James F. Lincoln Arc Welding Foundation. The awards will be made for the best papers describing design im-

Topics

Cherchez la femme: a new angle in recruiting engineers. A California firm seeking electronics engineers advertised in the women's section of the newspaper, inviting the ladies to visit Disneyland with the children while their husbands interviewed for jobs.

• • •

One of the country's most modern communications systems will be installed along Massachusett's new east-west turnpike, to provide swift communication for state police patrolling the road and for highway maintenance crews. The system, to be built by General Electric, will link VHF and microwave radio equipment. It will cover more than 180 miles.

• • •

Talking pictures can be made by the home movie enthusiast by means of a new German development called the "talking pencil line." This is an 0.8-mm magnetic band that runs beside the perforation on 8-mm film. A tiny magnetic head records sound onto the strip.

• • •

More working hours for technical personnel has been proposed to combat the manpower shortage. Carl Setterstrom, councilor of the American Chemical Society, said recently that scientists and engineers should work 45 hours a week until the age of 70. Such interesting work, he maintains, should not be limited to a mere 35 hours a week.

• • •

United Engineering Trustees Inc. has signed a contract for preliminary architectural plans and studies for a new engineering center in New York City. UET is composed at present of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers and the American Society of Civil Engineers. Preliminary plans for the new engineering center are to be completed early next year.

• • •

American Lithium Institute has been established for the purpose of conducting research on lithium and its compounds. With offices in Princeton, N. J., the institute will maintain a technical library and literature service.

Circle 407 on page 19→

Yours.. for the asking

The proper material for sintered bronze or iron bearings has always been a major problem to design men. Now for the first time a chart has been engineered, clearly showing the complete chemical, mechanical, and work characteristics of a wide range of sintered bearing materials. The best material for most applications can be selected by a draftsman in a matter of minutes. Only requests on company stationary will be honored.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO. EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

provements through arc welded steel fabrication. A booklet concerning the competition is available from the James F. Lincoln Arc Welding Foundation, Cleveland 17, O. Entries must be received in Cleveland by July 17, 1957.

Guided Missile Fleet Now Has Floating Benchmark

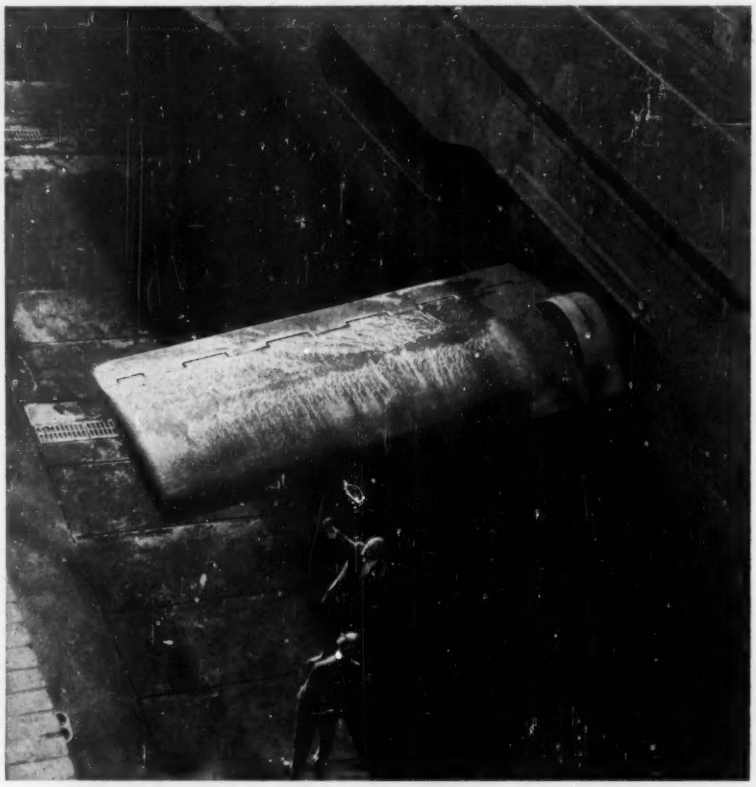
NEW YORK, N. Y.—Packed with navigational equipment that make it actually a sea-going observatory, the Navy's experimental ship *Compass Island* was commissioned at the New York Naval Shipyard, December 3.

A converted Mariner-class cargo vessel, the *Compass Island* is equipped with "the most fantastic array of navigation instruments ever assembled in a ship," the Navy says. Its mission is to speed evaluation of new inertial aids for precise mid-ocean navigation, independent of shore-based aids, and to expedite launchings of the Fleet Ballistic Missile.

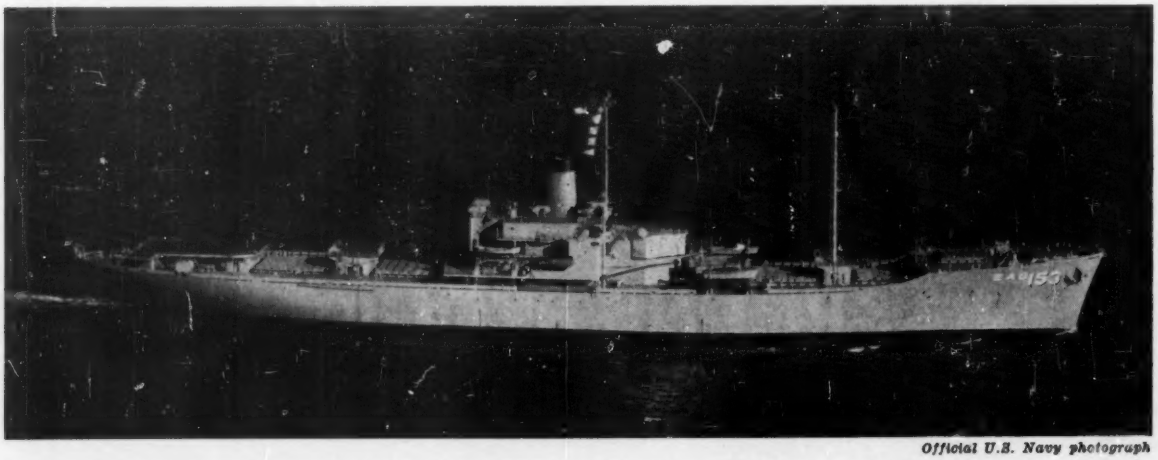
Key to the ultimate, all-weather, all-latitude, day and night capability is the ship's inertial navigational system, named SINS. The system determines continuously the ship's position (latitude and longitude), true North, and the ship's speed over the sea bottom.

To check and periodically correct SINS, the *Compass Island* will have several celestial trackers or miniature observatories. The trackers will automatically follow navigation stars, giving continuous celestial information for determining positions. The telescopes need no observers. They contain photoelectric cells so sensitive that stars become visible in daylight.

The observatories are mounted on a 67-ton navigational tower located just forward of the ship's superstructure. The tower provides a



Gyrofins on the experimental Navy ship *Compass Island* contribute to the stability of the ship at sea and, in turn, the accomplishment of celestial observations which help aim missiles. The fins cut normal roll 90 per cent.

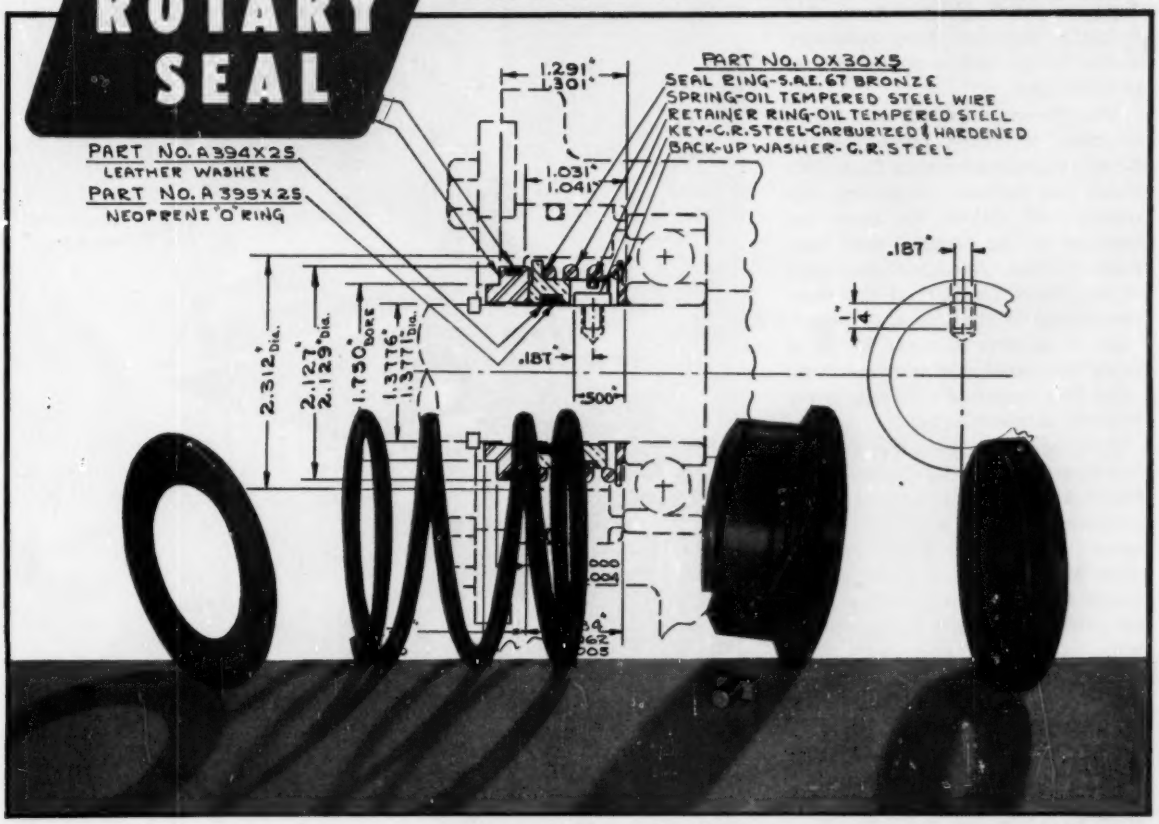


Official U.S. Navy photograph

U. S. S. Compass Island, converted from a Mariner-class cargo ship, carries a celestial observatory and precision sonar. Its position at sea will be basic data for the U. S. guided missile fleet.

ROTARY SEAL

SPECIALIZED SEAL ENGINEERING



is developing new ways to assure top performance in HIGH-PRESSURE HYDRAULIC OIL PUMPS

In modern pump design, pressures keep climbing, overall sizes keep shrinking—and the Shaft Seals must be better designed to handle tougher operating conditions.

Take a Seal like that illustrated: it's one of a series developed by ROTARY SEAL engineers, for heavy-duty pumps which activate big 'dozers and similar equipment. High pressures provide higher out-put efficiency; and the Seal must take the whole load—no shunting or bypassing part of it—yet must be designed to take up less space in extra-compact units.

You can't reach back on the shelf for a Shaft Seal when your pump—or your compressor, or whatever your unit may be—must measure up to tougher modern specifications. It takes a *custom-designed* Seal—fitted in every detail to the specific job at hand. ROTARY SEAL specializes in developing and manufacturing Seals to meet such problems, by applying the basic ROTARY SEAL principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago.

Major assignments for important Seal developments are keeping us mighty busy at present; but if special difficulties are besetting your development programs, and production quantities of Seals are involved, we'll be glad to help if we can.

THE ROTARY SEAL Division of MUSKEGON PISTON RING CO.
mechanical seals for rotating shafts

Shaft-Sealing with Certainty

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U.S.A.

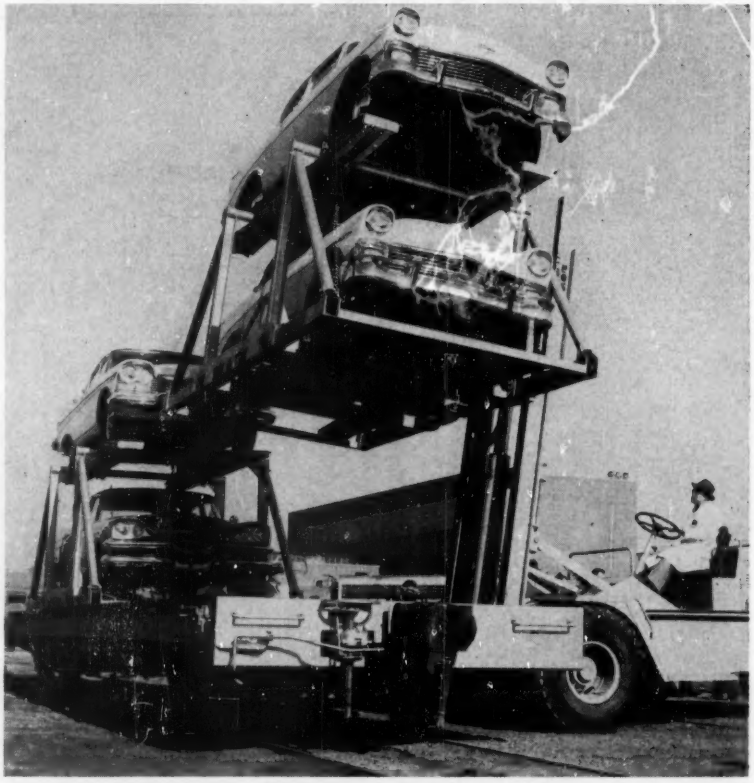
Circle 408 on page 19

rigid structure, isolated from ship flexures, to give fixed reference planes from which to make celestial observations.

The *Compass Island* will be an accurate reference point for the Navy's missile-launching fleet. "We know the ballistic trajectory our missile will follow; we know the location of the target," said Garrison Norton, Assistant Secretary of the Navy for Air, at the commissioning of the *Compass Island*, "but to achieve success we must know the location of our launching point to a degree of accuracy never hitherto attained at sea."

A complex airfoil-shaped dome has been added to the bottom of the ship's hull to house special sonar equipment to measure the ship's speed. This dome is designed to make the reading of sonar echoes easier and more precise than present systems while the ship is steaming.

The *Compass Island* will be one of the most comfortable-riding ships in the Navy. She has the best automatic steering available and activated fins for roll-stabilization. This system was developed in the U. S. by the Sperry Gyroscope Div. of the Sperry Rand Corp. When other ships are rolling 15 degrees, the *Compass Island*, in the same seaway, will roll about a degree and a half.



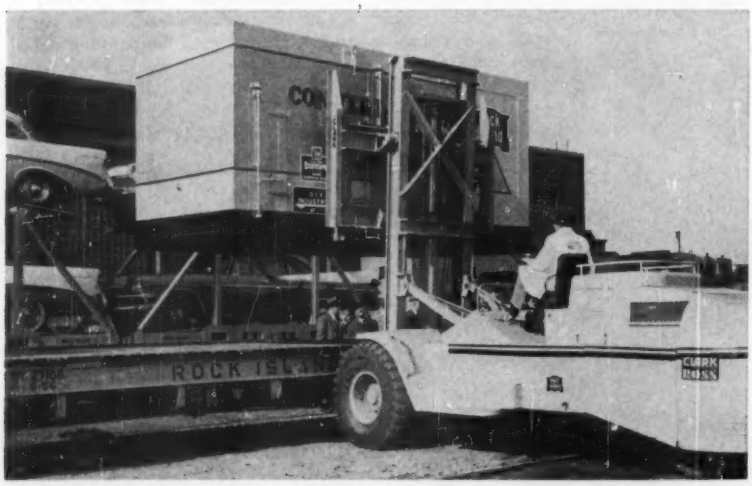
Convert-A-Frate automobile transport units are loaded on a four-wheel lightweight flat car 38 ft long. Without removal from transport frame, the autos can also be carried on highway trailers, and the flat car then converted.

Lightweight Freight Cars Convert for Varied Cargo

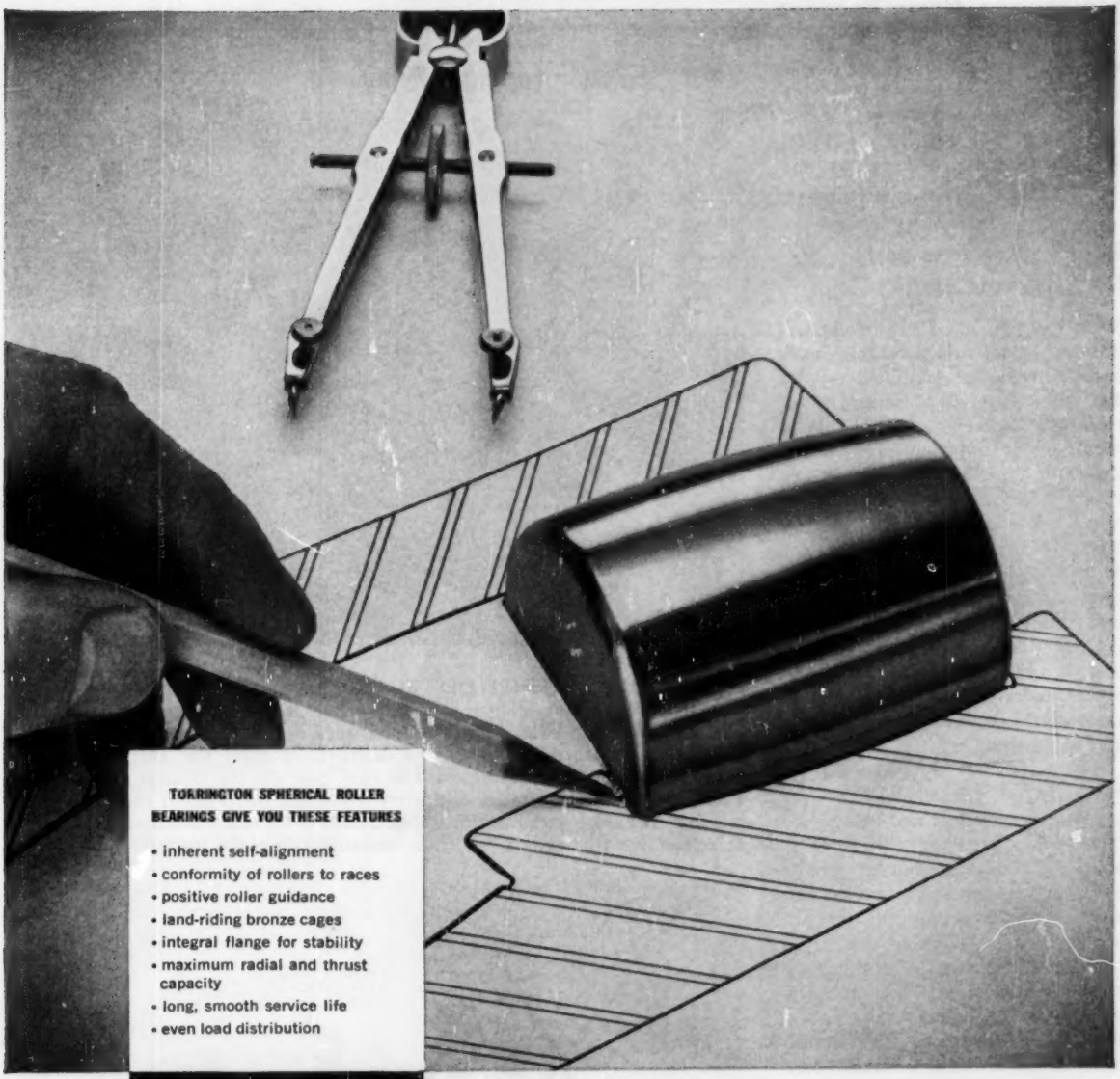
CHICAGO, ILL.—Four-wheeled flat cars with convertible cargo bodies are the feature of a new freight-handling system introduced by the Rock Island Lines and called Convert-A-Frate. The new system is the Rock Island proposal for speeding up freight delivery and extending freight service without the expense of new lines and sidings.

The constant element in the system is a 38-ft flat car which features roller-bearing two-wheel trucks at each end instead of the current standard four-wheel arrangement. The cars have rubber draft gear, standard couplers, and a loading floor 42 in. above the rail surface.

The variable element of Convert-A-Frate is the flat car's cargo body. Types of bodies to be available include box, covered hopper, gondola, hopper, tank, refrigerator, and an automobile carrier. The bodies can be interchanged on the cars by conventional fork-lift trucks and carried on highway trailers between shipping or receiving plants and the railroad. Cargo bodies can



Refrigerated cargo unit for Convert-A-Frate service is built of plastic sandwich panels bonded with epoxy resin. Sides and roof are 5¾-in. balsa cores faced with ⅛-in. isotropic plastic skin. This unit, 17 ft long, carries 14,000 lb.



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- inherent self-alignment
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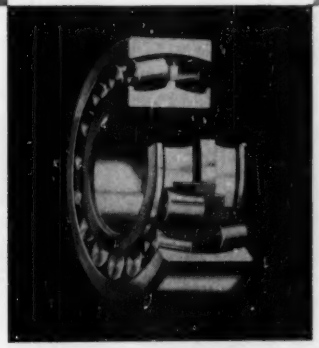
- land-riding bronze cages
- integral flange for stability
- maximum radial and thrust capacity
- long, smooth service life
- even load distribution



Mated perfectly ~ for life!

Make a point to notice the roller end and center guide flange in a Torrington Spherical Roller Bearing. The perfect mating there means a smoother, longer bearing life.

Roller end and flange surfaces alike are ground to a common spherical radius centered on the common vertex of bearing axis and roller axis. Under all load conditions, the rollers bear lightly but constantly against this flange. This guides the roller positively with minimum friction and prevents skewing. Stress concentrations leading to early failure are avoided, so the bearing will serve you many good turns longer.

This is the kind of feature Torrington builds into its bearings out of its experience with all major types serving in all kinds of equipment. Care for such details is matched only by our care in mating the *right* bearing to the *right* job. In this, your Torrington representative is an expert: call on him when you need help. *The Torrington Company,* South Bend 21, Ind.—Torrington, Conn.

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SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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also be handled by crane and moved by roller conveyor. Modular sizes of cargo units are 8 x 8 x 8 ft, 8 x 8 x 17 ft and 8 x 8 x 35 ft. A single flat car will receive one to four units.

More Volume Uses Seen For Reinforced Plastics

NEW YORK, N. Y.—Reinforced plastics are penetrating volume markets formerly held exclusively by die cast aluminum, porcelainized steel and molded plywood. This is reported by the Reinforced Plastics Div. of The Society of the Plastics Industry Inc. in its current review of 1956 and forecast for 1957. The industry recorded a 30 per cent gain in sales in 1956 over 1955 and predicts an equal percentage growth in 1957.

Growth of the industry is credited to advances in processing and better understanding of the use of reinforced plastics by designers and engineers.

The advances in processing involve faster curing resins, new types of compounds and better materials handling methods. For example, the development of premix compounds, combining resins and short chopped reinforcing materials, has made possible the injection and compression molding of reinforced plastics. New and improved preforming equipment and processing have also been developed that substitute mechanical for hand labor.

Advances are also being made in the hand lay-up phase of the industry with the result that very large units—40-ft boats for example—can more easily be made in one piece.

Fields for applications of reinforced plastics in the year ahead are the transportation industry, household appliances, furniture and seating, containers, construction and electrical components.

Present production and future potential for reinforced plastics in automobile and appliance manufacture can be traced to two main factors: (1) reinforced plastics' ability to be formed in large one-piece units and, (2) use, in some cases, of inexpensive tools.

Two "Firsts" for the Navy

Official U.S. Navy photograph

FIRST GUIDED MISSILE DESTROYER, the *U. S. S. Gyatt,* heads out to sea from the Boston Naval Shipyard where it was commissioned Dec. 3. The *Gyatt* carries twin Terrier guided missile launchers and modern anti-submarine ordnance. It is the first destroyer to carry the Terrier, but the third Navy ship thus equipped. The first two are the cruisers *Boston* and *Canberra.* In addition to its distinctive ordnance, the *Gyatt* is the first Navy warship to have a stabilization system added to its hull structure. Two 45 sq ft retractable fins extend out from midships below the waterline.

Official U.S. Navy photograph

FIRST AID FOR LANDING CRAFT is the mission of this new recovery vehicle, designated LVTR-1. The Marine Corps will receive 14 to be built by Food Machinery and Chemical Corp. The LVTR-1 is a tracked, amphibious landing vehicle used for recovery and maintenance of other landing vehicles disabled in combat. Each LVTR is equipped with a 7000-lb capacity crane; a 40,000-lb capacity winch; welding equipment and basic tools. Dimensions are: weight, 41 tons; length, 32 ft; width, 11½ ft; height 10½ ft.

News Roundup

Production of reinforced plastic automobile bodies continues at an increased rate and tooling for the next model of the Chevrolet Corvette is now underway, but the volume growth of reinforced plastics in cars is in components.

Reinforced plastic airplane wings have been announced recently by Fairchild Engine and Aircraft Corp. and reinforced plastic pipe is being more widely used by oil and gas producers and the chemical industry to solve the problem of corrosion.

Protective Coatings Plated on Titanium

WASHINGTON, D. C.—Hard, protective coatings have been successfully electrodeposited on titanium at the National Bureau of Standards. The procedure involves forming a titanium-fluoride film on the metal surface, electroplating with chromium, and heat-treating the plated specimen at 800 C. Developed for the Springfield Armory, the process is expected to extend the utility of titanium, particularly for high-temperature applications.

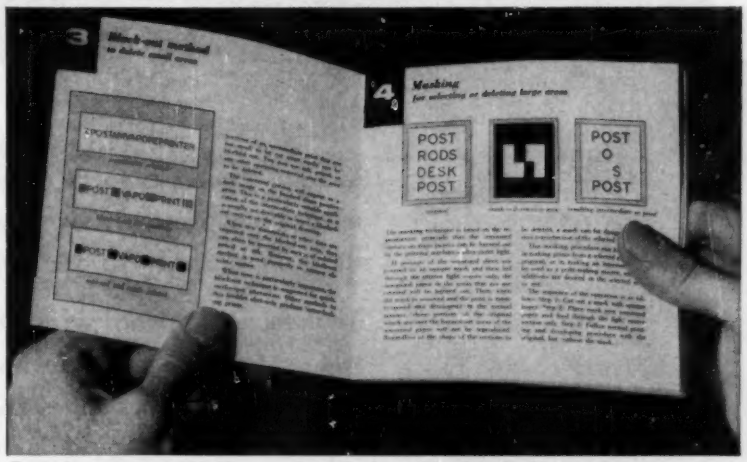
Because of titanium's high strength-to-weight ratio, it ranks with steel and aluminum as a structural material. However, titanium has disadvantages for some applications: It tends to gall or seize when in loaded contact with itself or other metals, and it oxidizes at elevated temperatures. These disadvantages can be minimized if titanium is coated with hard, oxidation-resistant metals such as chromium or nickel.

The main problem in depositing metals on titanium is lack of adhesion—some deposits have flaked off during the plating operation and others have been easily pulled off with the fingers. Poor adhesion has been blamed on an oxide film on the base metal, but attempts to remove the suspected film with acid etches or anodic films had not been successful.

The Bureau conducted an experiment which supported the hypothesis that a film, probably an oxide, exists on the surface of ti-

(*Continued on Page 22*)

DRAFTING TRENDS



Typical pages from "11 Ways to Save Drafting Time," a booklet on the use of intermediates. Each technique is fully described and illustrated with specific examples.

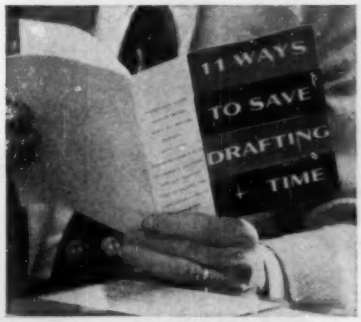
Helpful booklet on drafting tips offered again

An interesting booklet called "11 Ways to Save Drafting Time" is available without charge to engineers and draftsmen. Published by Frederick Post Company, it compiles the many ways of using *intermediates* to modify drawings without changing the original.

As most draftsmen know, an intermediate is any translucent reproduction master printed from an original drawing. Once the drawing is printed on the intermediate, this "duplicate master" serves as the source for future print making. By modifying only the intermediate and leaving the original unchanged, draftsmen save valuable hours of tracing and redrawing.

The booklet shows 11 specific ways of using intermediates to make changes, each one illustrated with examples. Some of the techniques covered are scissor editing, masking, the block-out method, successive additions and preprinting.

The other methods shown are transparent matte tape, pick-off transfer, composite grouping, composite overlays, non-reproducible blue and use of corrector fluids.



Intermediates can be used in a variety of ways to cut costly retracing, changing and modifying of drawings.

The techniques described apply to various print-making methods such as moist-developed process, ammonia process, blueprint, sepia negative and even reproduction cloths in some instances.

Further information on the new "11 Ways" booklet is available from the Reader Service Division of the Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

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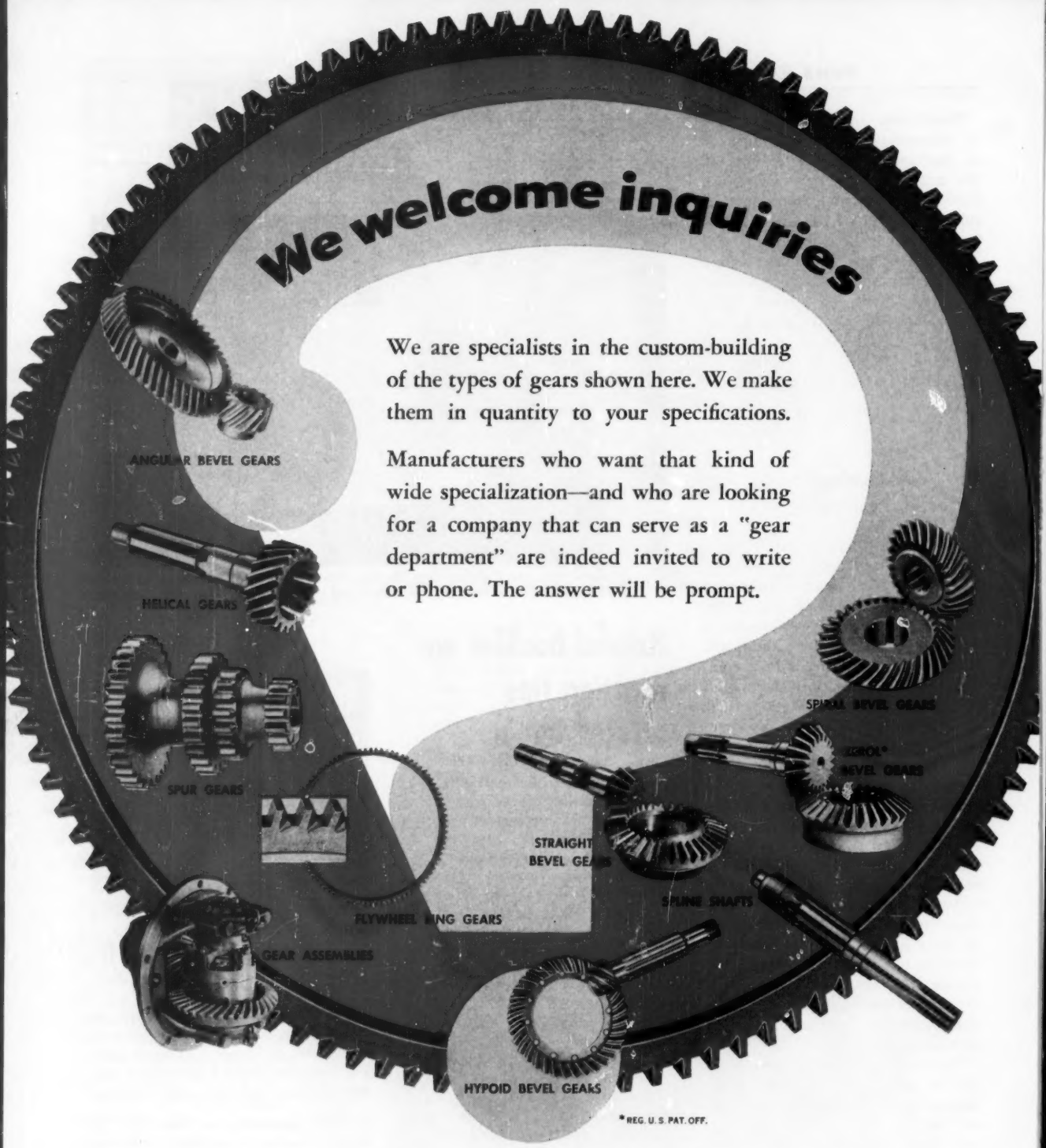
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GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 411 on page 19

MACHINE DESIGN
READER SERVICE

Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
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414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
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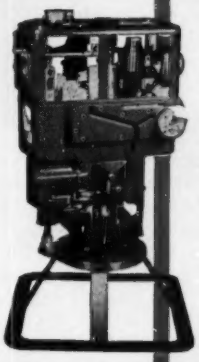
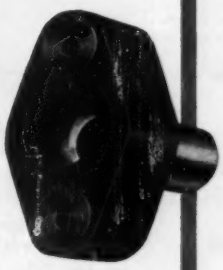
5 practical ways to "streamline"

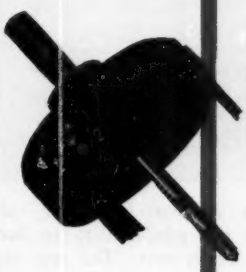
...without sacrificing fastening strength



1. Counterbored holes are the simplest approach to flush surfaces using standard socket cap screws. The advantage of specifying genuine Allen O Head Cap Screws is the greater strength of Allenoy steel... you can use smaller sizes for closer spacing and reduced weight. Call on Allen, too, for *very large* socket-head, precision cap screws — up to 2½ inch diameter.



2. Countersinking enables you to get absolutely smooth external surfaces using Allen O Flat Head Cap Screws. Allen O Cap Screws feature the exclusive Leader Point which makes screw starting easier and guards against thread damage.



3. Button Head Cap Screws produce snag-free unbroken surfaces where countersinking is impractical. Button-head hex sockets are necessarily shallow. In genuine Allen O Button-Head Cap Screws, sockets are cold forged without broaching, in extra strength Allenoy steel... essential protection against stripping the sockets under high torque pressure.

4. A ready made hole tapped in forged steel solves many a design problem. It's called the Allenut. It can be anchored in soft material to assure durable threading, or recessed to permit tightening with an Allen Hex Key.

5. Bright finish, or rust and corrosion resistance call for Allen O Stainless Steel Cap Screws. They are standard stocked items (both NF & NC threads) readily available in a wide range of sizes from Allen Distributors.

YOUR ALLEN DISTRIBUTOR can give you practical help and swift service. For complete information on any technical fastening problem, write our engineering department direct.

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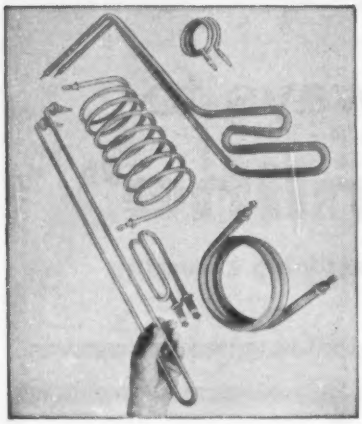

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Circle 413 on page 19

Engineering News Roundup

PLYMOUTH'S FURY accommodates six passengers and is built to perform like a sports car. It has a 290-hp engine with eight-barrel carburetion. Bore and stroke are 3.91 by 3.31 in.; displacement is 318 cu in.; and compression ratio is 9.25 to 1. The Fury has dual exhausts, special domed pistons, high-intensity cams, and high-load value springs. Exterior finish is white, with gold-colored trim in the form of anodized aluminum strips on the sides and a gold-colored aluminum grille. The interior color scheme is cocoa and beige.

"TRANSCONTINENTAL" SAFARI, Pontiac's custom four-door, six-passenger station wagon for 1957, is designed for adaptability to long trips. It features a four-position reclining right front seat. The seat also has a folding head rest. A roof-top luggage rack with an Orlon cover provides cargo space in addition to that inside the wagon. The Safari is powered by a 290-hp engine with triple two-barrel carburetors. New shock absorber valving and rear springs with special liners are claimed to provide a level, untiring ride.

(*Continued from Page* 15)

tanium and impairs the adhesion of metal deposits. In subsequent experiments, the best chromium platings were obtained by pretreating titanium to form a coating of titanium fluoride before plating a specimen. This procedure appears to prevent the formation of an oxide. When the specimen is placed in the plating bath, the titanium fluoride dissolves, permitting the chromium to bond directly to the basis metal.

At the start of the new process, titanium specimens are thoroughly degreased and cleaned before the treatment. Next they are dried and suspended in a solution of hydrofluoric and acetic acids. After 10 or 15 minutes, 60-cycle alternating current is passed through the specimen for another 10 minutes. The specimens are then rinsed and transferred to a conventional chromium plating

for heavy-duty shock load service...

which bearing is best?

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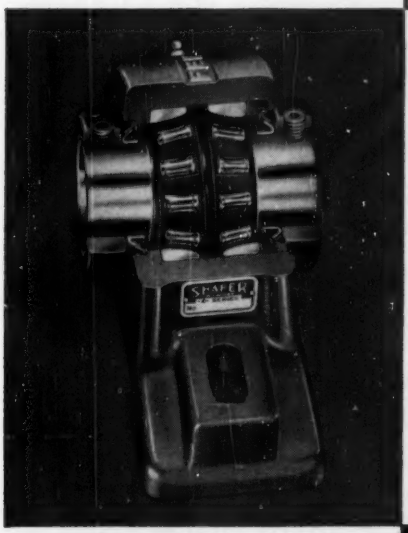
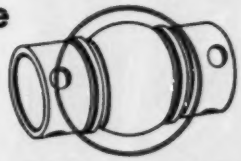
Low Friction Loss	✓		✓
Self-Alignment	✓		✓
High Radial Load Capacity		✓	✓
High Thrust Load Capacity		✓	✓
High Shock Load Reserve		✓	✓
Long Life		✓	✓
Fast, Positive Adjustment			✓
Lowest First Cost	✓		
Lowest Over-All Cost			✓



SHAFER Self-Aligning Roller Bearings give you more

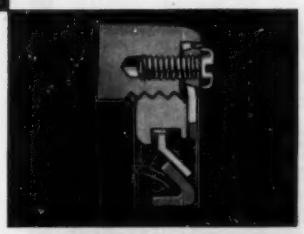
Shafer design combines both the low rolling friction of a ball and the high load carrying capacity of a roller. Under shock loads, continuous heavy-duty loads—even under conditions of misalignment—Shafer Bearings maintain full load capacity. You can get off-the-shelf delivery of standard pillow blocks, flange units, flange cartridge units and take-up and frame units. Call your nearby CHAIN Belt District Office Representative or Distributor.



Inner race is segment of a ball.

Roller presents matched curve surface.

and...



"Z" seal keeps dirt out ...grease in

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Shafer exclusive Micro-Lock provides 12-point adjustment compensating for wear or unusual operating conditions.

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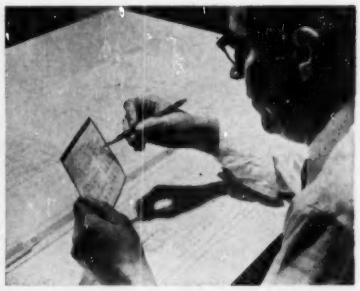
News Roundup

bath, where they are plated at a temperature of 85 C and a current density of 120 amp/dm^2.

Tensile strength tests indicate that adherence of the cromium coating to titanium is greatly improved by heat-treating the plated specimen for 2 minutes at 800 C in an inert atmosphere. Bond strength of the heat-treated specimens ranged from 4000 to 18,000 psi. Although the highest value obtained is somewhat below the tensile strength of heat-treated chromium, fracture occurred in all cases in the chromium plate and not between the two metals.

Coatings on titanium consisting of 0.02-mm of chromium plus 0.15-mm of nickel were found to be moderately adherent without heat treatment, but not comparable to that of chromium on steel.



CARD-SIZE FILM PRINTS of engineering drawings are the products of a new reproduction system, called Micro-Master, recently introduced by Keuffel & Esser Co. Equipment tailored to the process makes 4 by 6-in. prints on several kinds of 105-mm film, including card stock, above. Micro-Masters are claimed particularly suitable for large size original drawings, up to 36 by 54 in., the prints of which can be read without magnification.

Radiation Laboratory to Study Effects of Rays on Rubber

AKRON, O.—First of its kind in the rubber industry, a radiation laboratory has been opened by the Goodyear Tire and Rubber Co. Mission of the laboratory is the exploration and development of rubber products which will perform satis-

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factorily in a radiation environment.

Rubber is particularly susceptible to radiation. Exessive doses are invariably damaging, usually leading to hardening and embrittlement. Using radioactive cobalt, Goodyear will search for the most favorable compounding practices and for chemical additives to improve radiation resistance, along with resistance to heat and oils.

One of the more important projects contemplated is development of radiation-resistant airplane tires which could be used on atomic-powered aircraft of the future.

Other goals of the irradiation program will be to initiate chemical reactions, polymerization and vulcanization of rubber and to improve physical properties of plastics and resins.

For most types of raw rubber, irradiation results in vulcanization. Among the many possibilities in this field is that vulcanization can be accomplished without adding sulphur or other chemicals.

Wire Is Aluminum Coated For Longer High-Temperature Use

PITTSBURGH, PA.—A protective aluminum "skin," 0.0025-in. thick, has been placed on copper wire by Westinghouse engineers. The skin promises to increase the life, reduce the size and raise the efficiency of present-day electrical equipment by enabling it to operate over long periods of time at higher temperatures than are now practical.

With a new metallurgical technique, the wire is encased in a thin, protective coating of aluminum, to which is then added a second coating of high-temperature insulation. The wire product combines the electrical conductivity of copper, the oxidation resistance of aluminum, and the added protection of insulating enamel.

Modern insulating materials withstand heat so well that the copper wire itself is becoming a limiting factor. No insulation completely seals a wire from the air, which eventually seeps through to attack the copper. At high tem-

load cells

based on the Statham unbonded strain gage transducer

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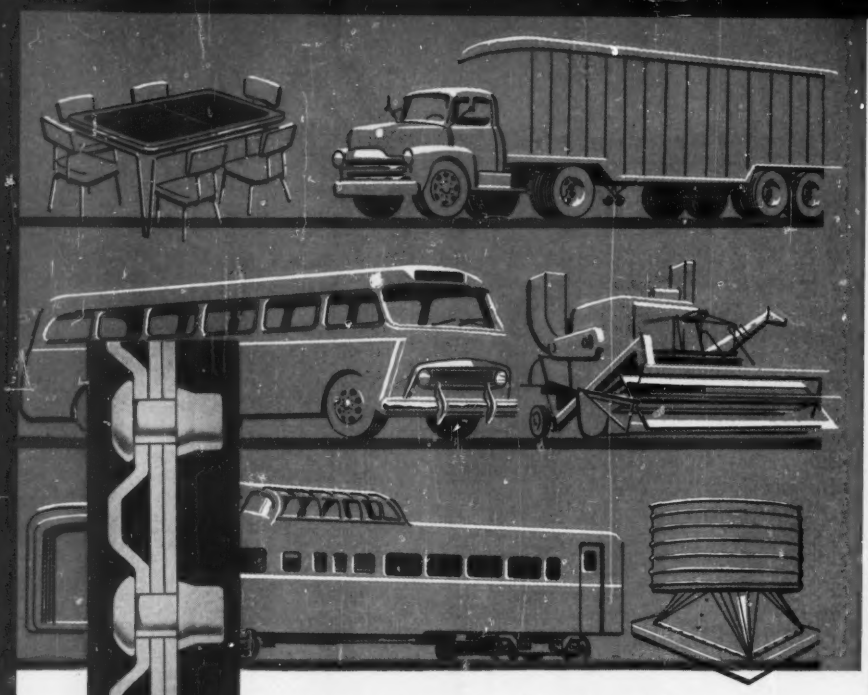

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Get Uniformly Secure
Permanent Fastening
With Townsend Lockbolts**

The Townsend lockbolt provides a quick method of producing uniformly secure fastenings that cannot loosen even under extreme vibration or shock conditions. They combine the advantages of riveting and bolting—eliminate the disadvantages.

Typical users are manufacturers of railroad cars, highway trucks and trailers, buses, farm equipment, industrial ventilators, and furniture. They find that the use of Townsend lockbolts gives them an opportunity to improve their products—reduce unit costs.

These benefits are possible for several reasons. By use of Townsend lockbolts, fewer and less skilled workers can complete an assembly faster than by other methods because the setting action does not depend upon the skill of the operator. The clamping action, or tensile preload is higher than rivets—is more uniform than bolts and nuts. The lockbolt makes possible a more rigid joint because it fills the hole better than other fasteners.

Townsend lockbolts are available in steel and aluminum alloy, in 3/16", 1/4", 5/16", 3/8" and 1/2" diameters, in grip lengths ranging up to 2" in various head styles. Other material and lengths available upon request. They are described in Sweet's design file and in Townsend bulletin TL-101.

For a demonstration at your desk of how to get better, economical fastening with Townsend lockbolts, write on your company letterhead to Townsend Company, P. O. Box 237-E, New Brighton, Pa.

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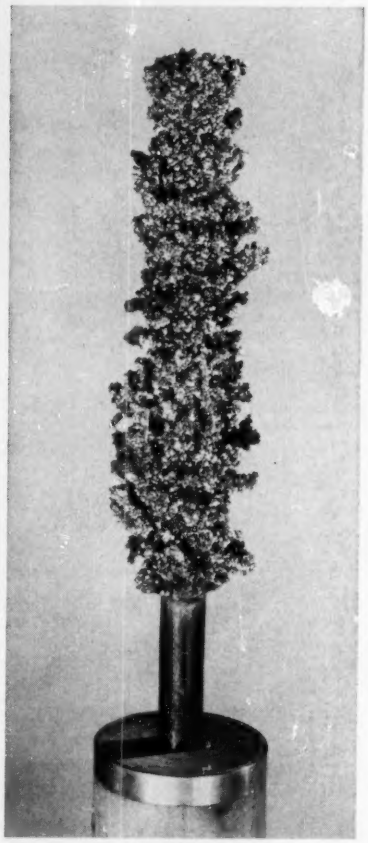
Circle 418 on page 19

peratures, the copper unites chemically with oxygen to form a layer of copper oxide. This layer gradually grows in depth, causing the insulation to degrade. In addition, it decreases the size of the wire and lowers its ability to carry electric current.

The Westinghouse technique is to cover the wire with a thin film of aluminum. Unlike copper, the oxide formed on the surface of aluminum does not grow appreciably.



TITANIUM TREE has been grown in an electrolytic refinery vessel by Mallory-Sharon Titanium Corp. in experiments to recover the metal from scrap. High purity titanium was obtained from random scrap which formerly needed careful classification. The electrolytic metal has brinell hardness of 60 compared to 120 to 140 for commercial grade. A new recovery plant is to be built for the process.

When only about 0.0000004-in. thick, it forms a self-protecting coating which prevents further penetration of oxygen. Thus, a very thin coating of aluminum will effectively isolate a copper wire from attack by oxygen in the air.

On an aluminum-clad copper wire about the size of the lead in an ordinary mechanical pencil, the aluminum is about 0.0025-in. thick. The covering must be very thin because aluminum is a poorer electrical conductor than copper. The wire made at Westinghouse shows a conductivity about 85 per cent of the International Annealed Copper Standard.

Biggest problem in developing a successful aluminum-clad wire, was getting the aluminum to adhere properly to the copper while preserving the natural ductility of the separate metals. A copper rod is first plated with a layer of silver, which acts as a barrier to the interaction of the two metals.

The silver-plated copper rod is then inserted into a thin-walled tube of aluminum. The aluminum-jacketed rod is rolled into a rod of smaller diameter and then drawn through dies into wire of the desired size and shape.

Engineer Shortage Must Not Compromise Personnel Quality

NEW YORK, N. Y.—More engineers than are graduated this year would be added to the nation's technical labor force if companies could use their present engineers just 5 per cent more effectively. This was the estimate of Dr. Lee Dubridge, president of the California Institute of Technology, quoted by Clifford F. Hood, president of U.S. Steel, speaking at a recent meeting of the Manufacturing Chemists' Association.

Mr. Hood outlined many other approaches to the problem of the current engineer shortage but cautioned that none of them may be allowed to compromise the quality and competence of technical personnel.

"We must not be panicked into any wild schemes which might destroy the goals of higher education

A good point to consider...

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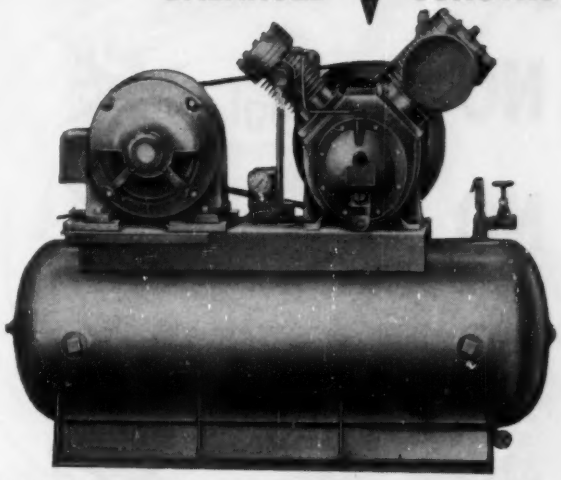

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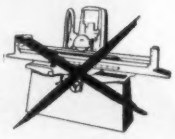

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SURFACE BONDED... THEY peel FOR ADJUSTMENT

Laminated Shims of LAMINUM now available in

STAINLESS STEEL with laminations of .002" or .003"	ALUMINUM with laminations of .003" only
BRASS with laminations of .002" or .003"	LOW CARBON STEEL with laminations of .002" or .003"

LAMINATED SHIM COMPANY, INC.

Shim Headquarters since 1913

1201 Union Street, Glenbrook, Conn.

or tend to emphasize quantity first and quality second. I am certain that industry and educators alike want to follow a sane and reasonable course, to the end that the demand for number may not outstripe the demand for knowledge.

"Close attention to quality, for example, could lead to a greater number of candidates for doctorate degrees. I am reminded that this year substantially less than 10 per cent of degrees awarded in science will be at the Ph.D. level. Yet it is upon this area of advanced scientific knowledge that our nation must depend if we are to encourage more pure research. The progress of (the chemical) industry during the past quarter of a century illustrates that outstanding work has been done here in pure research. Unquestionably, such efforts will continue. But we should remember that the scientist capable of advanced thinking must be discovered, developed and often assisted financially during his long years of preparation and study."

Meetings

AND EXPOSITIONS

Jan. 21-22—

Solar Furnace Symposium to be held at Hotel Westward Ho, Phoenix, Ariz. Sponsors are the Association for Applied Solar Energy, Stanford Research Institute, Arizona State College and the University of Arizona. Further information can be obtained from Mr. John I. Yellott, 3424 N. Central Ave., Phoenix, Ariz.

Jan. 21-25—

American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler, New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

January 24-25—

Digital Computer Symposium to be held at the Franklin Institute, Philadelphia. Further information

is available from Automatic Coding Symposium, Franklin Institute, 20th and Parkway, Philadelphia 3, Pa.

Jan. 28-31—

Plant Maintenance and Engineering Show to be held at the Cleveland Public Auditorium. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

February 4-8—

American Society for Testing Materials. Annual Committee Week and Spring Meeting to be held at the Benjamin Franklin Hotel, Philadelphia. Additional information is available from society headquarters, 1916 Race St., Philadelphia 3, Pa.

Feb. 5-7—

Society of the Plastics Industry Inc. Twelfth Annual Technical and Management Conference of the Reinforced Plastics division, to be held at the Edgewater Beach Hotel, Chicago. Further information is available from society headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 15-16—

National Society of Professional Engineers. Spring Meeting to be held at Hotel Francis Marion, Charleston, S. C. Further information is available from society headquarters, 2029 K St., N. W., Washington 6, D. C.

Feb. 24-28—

American Institute of Mining, Metallurgical and Petroleum Engineers. Annual Meeting to be held at the Hotel Jung, New Orleans. Additional information can be obtained from the institute's headquarters, 29 W. 39th St., New York 18, N. Y.

February 25-March 1—

American Society of Heating and Air-Conditioning Engineers. 13th International Heating and Air-Conditioning Exposition to be held at the International Amphitheater, Chicago. Further information is available from International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Draw a 300-mile circle around your plant —

You're almost certain to circle one of Milford's five manufacturing plants!

There's hardly a metalworking plant in the country that isn't within overnight trucking distance of one of Milford's five manufacturing plants. And 20 sales offices add to the convenience of ordering and *getting* rivets when you need them NOW!

To improve product appearance and strength
. . . to take full advantage of automatic assembly
. . . to cut delivery time and production costs
—get in touch with Milford first!

THE MILFORD RIVET

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MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

Circle 421 on page 19

ACTUAL PHOTOGRAPH

Fact 2 . . . up to 40% less space needed to stock. These new motors take less room in your product, too, because they are more compact in design.

New Westinghouse Design Cuts Motor Weight Up to 50%

. . . one important FACT about the new Westinghouse 48-frame fhp motor

Many cost-saving features make the new Westinghouse 48-frame your *best* motor buy. Lighter, smaller and more compact in design, it can be used to advantage in your product.

The lighter motor lets you use lighter mountings, lowering material costs. And it's easier to handle, faster to install on assembly lines. In many cases, your shipping costs will be lowered, too.

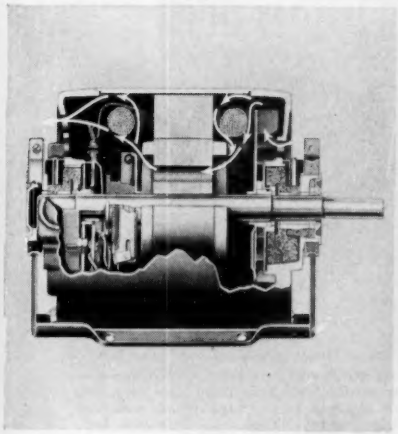
A new, lighter base—either rigid welded to frame or resilient—assures stronger mounting even under severe operating conditions.

It is the only true all-angle mounting motor. Don't expect all these benefits in any other motor.

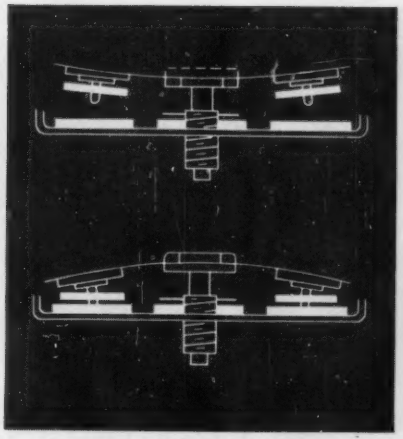
The Man With The Facts, your Westinghouse sales engineer, has all the information about this new fhp motor line. Contact him or write for DB-2801 for complete technical data. Westinghouse Electric Corporation, Small Motor Division, Lima, Ohio. J-03019

YOU CAN BE SURE...IF IT'S

Westinghouse



Fact 3 . . . straight-through ventilation of this new motor insures cooler operation for longer running periods, even at peak loads.



Fact 4 . . . exclusive Thermoguard® overload protection (optional). It opens (top) when overheating occurs . . . it resets when cool to resume operation.

Fact 5 . . . Mylar* insulation, one half as thick but possessing greater dielectric strength, provides better moisture protection, greater physical strength.

*DuPont Reg. Trade-Mark

Circle 422 on page 19

News about

B.F.Goodrich Chemical *raw materials*

PLUG VALVE *of Geon for handling corrosive fluids demonstrates molding of complicated shapes with integral threads. At the bearing surfaces Geon is molded to another plastic.*

LOOK WHAT THEY'RE MOLDING IN GEON RIGID VINYL...

All parts shown made by Tube Turns Plastics, Inc.

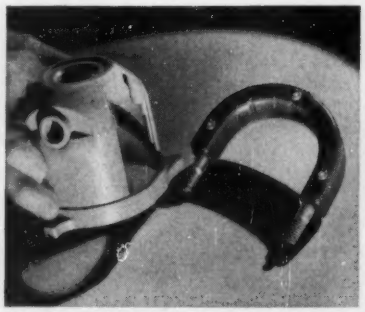
Geon polyvinyl chloride rigid compounds are recognized as outstanding materials for piping and fittings. Geon offers high impact and tensile strength, and superior resistance to oils, acids, alkalis, and most chemicals.

These same rigid compounds are being molded into many complicated shapes and parts in addition to piping components. Geon can be used in designs utilizing very thin sidewalls as well as heavy sections. Holes, studs, and threads can be made integrally. Parts weighing several pounds can be molded in one shot.

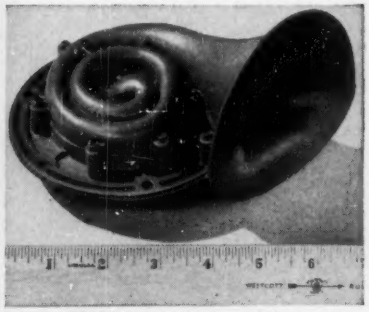
Despite design complexity, check Geon for strong, light, corrosion-resistant parts. For booklet on properties of rigid Geon compounds 8700A and 8750, write Dept. DO-1, B. F. Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ont.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

BIG FELLOWS *include piping tee and motor housing, requiring heavy cross section, chemical inertness, dimensional stability. By contrast, molding for automobile dashboard has thin section, large projected area.*



ELECTRICAL PARTS *include fractional horsepower motor housing which reduces appliance weight, and hanger band for transformer with Geon molded around metal bolt. Geon has excellent dielectric properties.*



AUTO HORN *trumpet shows complicated contours possible in rigid Geon. Note very thin walls obtained in this high-impact material. Photos courtesy Tube Turns Plastics, Inc., Louisville, Ky.*

B.F.Goodrich **GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors**

GEAR
Specialties, Inc.
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CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS
OF FRACTIONAL HORSEPOWER GEARING

IF YOU NEED VIBRATIONLESS GEARS
IT'S A JOB FOR
G. S. PATENTED GROOVES

G. S. research has now overcome *vibration and flutter* in Small Gearing for many vital applications. G. S. PATENTED GROOVES, as pictured here, successfully insulate vibrations of worm and gear teeth from reaching the shaft. Ultra smooth, *noiseless* operation is more than ever assured by the use of Bakelite Gears. ★ Whatever YOUR Gearing problem, you can depend upon G. S. research and engineering to lend powerful aid in reaching a successful solution. Here, you can, *without cost or obligation,* draw upon experience gained through 40 YEARS of specialization in the design and mass production of better Small Gearing exclusively. Send drawings and particulars today. Get the ONE best and most economical application for the job!

SEND FOR FREE *6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course. Write today!*

FRACTIONAL HORSEPOWER GEARING
GS

40 Years of Specializing in Small Gearing!

One in a series
on the application
of electric motors
in modern industry

This washer removes fly ash from cars left in the parking lot. The 25 hp. Reliance A-c. Motor automatically starts and stops 200 to 400 times a day in all kinds of weather.

These two Bauer Refiners are driven by Reliance 400 hp. A-c. Motors. The grinding action of the machines sets up heavy load factors on the motors.

RELIANCE motor design proved in new paper mill

Here is a 100 hp. Reliance Totally-Protected A-c. Motor doing a job under very adverse conditions. The water and pulp being sprayed on it is coming from a paper board machine, part of an installation that Crossett Paper Company recently built to produce bleached kraft board from hardwood and pine pulp.

But there is more to a Reliance Motor than just a good enclosure. Extra copper and iron, the best bearing lubrication system, tough, resistant insulation . . . these and many more features add up to designed durability, the one big feature that makes users, like Crossett, steady Reliance customers.

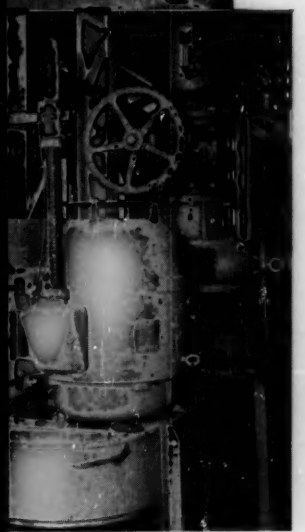
Call your Reliance representative and ask him to show you the Reliance extras. Fifteen minutes of your time now can save hours of machine down-time later.

For further details on this installation, write for bulletin B-2504. B-1835

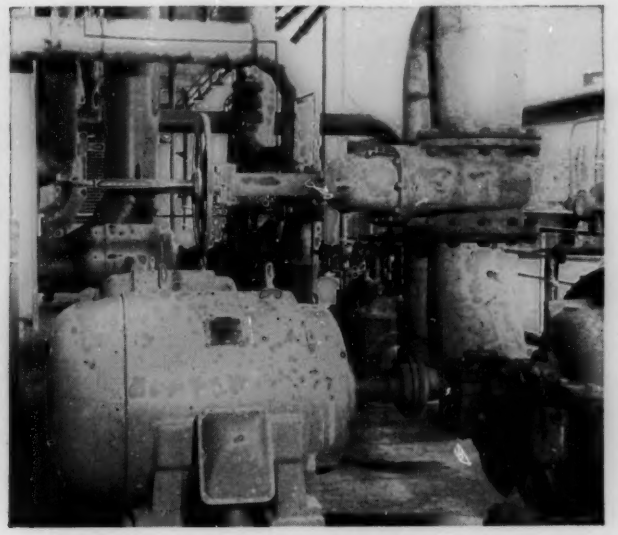
RELIANCE ELECTRIC AND ENGINEERING CO.

Dept. 281A, CLEVELAND 10, OHIO • CANADIAN DIVISION: WELLAND, ONTARIO
Sales Offices and Distributors in Principal Cities

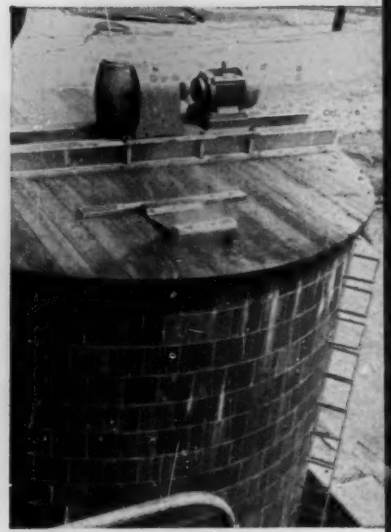
◀ Located under the head end of the board machine, this 100 hp. Reliance A-c. Motor operates a fan pump while periodically being drenched with water and pulp.



Reliance has frame designs for every application. Here is a 25 hp. foot mounted vertical motor driving a refined-stock pump. Other vertical designs include C-Face, D-Flange, and P-Base mountings.



This 60 hp., 1800 rpm and two 40 hp. 900 rpm Reliance A-c. Motors run white water pumps. Though reasonably sheltered from the elements, the motors are subjected to wide temperature changes.



In hard to reach spots like this two story high refined stock chest, Metermatic Bearing lubrication is very important. This new line 20 hp. Reliance A-c. Motor will operate the agitator for months without greasing.

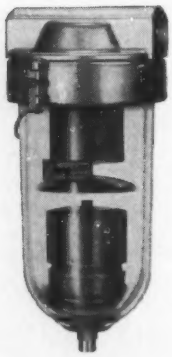
Circle 425 on page 19

Good News Norgren

for design engineers and PLANT ENGINEERS

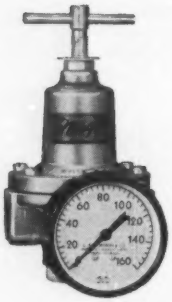
ANNOUNCES

Important New Developments in Compressed Air Filters and Pressure Regulators



NEW Norgren Air Line Filters

- **LESS PRESSURE DROP** — larger passages and larger filter element.
- **BETTER LIQUID REMOVAL** — Improved louver plate and baffle design. Removes more liquid from the compressed air line.
- **CHOICE OF FILTER ELEMENT**—interchangeable filter elements, 74, 64, or 25 micron.



NEW Norgren Pressure Regulators

- **GREATER ACCURACY OF REGULATED PRESSURE** — balanced valve and increased effective diaphragm area provide improved accuracy over a wide operating range.
- **RELIEVING OR NON-RELIEVING TYPE AVAILABLE**
- **IMPROVED RELIEVING CHARACTERISTICS** — automatic relief of excess pressure. Holds system pressure close to regulator setting.

For complete information...

call your nearby Norgren Representative listed in your telephone directory—or

WRITE THE FACTORY FOR NEW CATALOG.

C. A. NORGREN CO.

3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

Circle 426 on page 19

Circle 427 on page 19→

DU PONT

PRODUCT ENGINEERING NEWS

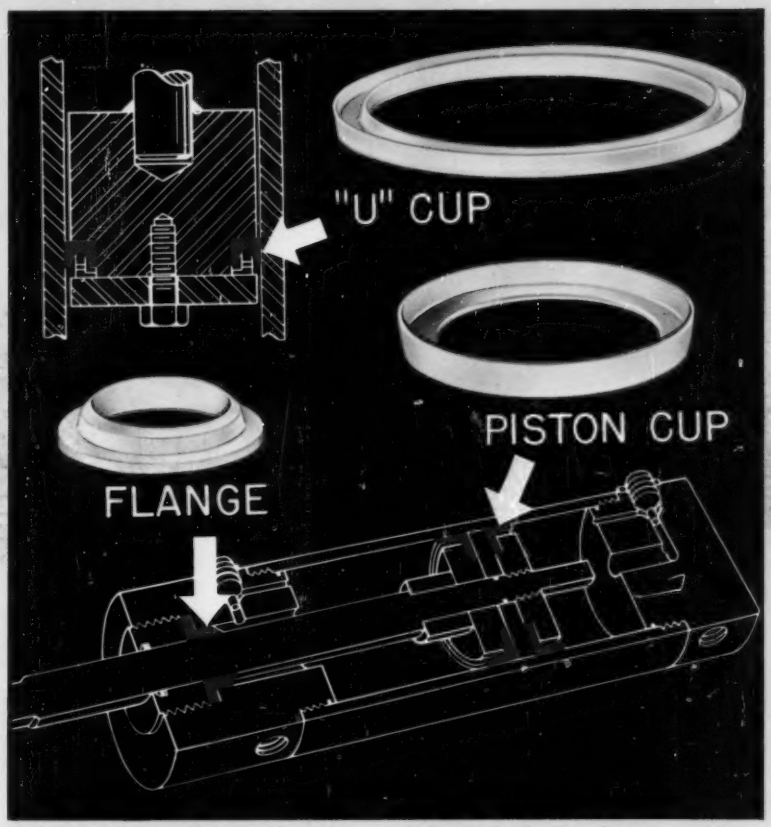
PROPERTY AND APPLICATION DATA ON "TEFLON" TETRAFLUOROETHYLENE RESIN

TEFLON® offers design possibilities unmatched by any other single material

MECHANICALLY, TEFLON tetrafluoroethylene resin offers high impact strength and toughness. This durable material can be used at temperatures to 500°F., and displays excellent properties at very low temperatures. TEFLON is weather resistant. Sticky or viscous materials do not adhere to its surface. The low coefficient of friction of TEFLON (kinetic coefficients of 0.04 and under have been measured) often eliminates the need for lubrication.

ELECTRICALLY, the power factor of TEFLON is less than 0.0003 over the measured spectrum (60 cycles to 10^8 cycles). Volume resistivity exceeds 10^{15} ohm-cm. Dielectric constant is 2.0 over the range tested (60 cycles to 10^8 cycles). Water absorption (ASTM D570-42) is less than 0.01%. TEFLON readily provides continuous service at 500°F., exceeding requirements of Class H materials.

CHEMICALLY, TEFLON is completely unaffected by all chemicals normally encountered in commercial practice. Exceptions to this include attack by the alkali metals under certain conditions. At elevated temperatures and pressures, halogens and certain halogenated chemicals and solvents may affect it. Through the use of TEFLON tetrafluoroethylene resin, reduction of maintenance costs and downtime, as well as simplified design, have been achieved in many chemical installations.



Packings of Du Pont TEFLON withstand the severe temperatures and pressures in hydraulic cylinders. Components made of TEFLON tetrafluoroethylene resin do not harden, shrink or swell—are unaffected by hydraulic fluids. The piston cups, U-cups and flange packings shown above are made from Du Pont TEFLON tetrafluoroethylene resin by the Crane Packing Company, Morton Grove, Illinois.

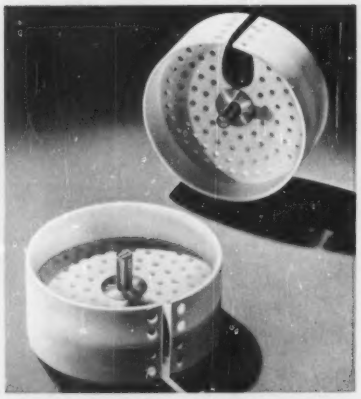
TEFLON Can Now Be Cemented with conventional adhesives, owing to a new process. Good bonding strength can be achieved between the cementable TEFLON and wood, glass, steel, aluminum, copper, ceramics, plastics—in fact, any material on which commercial adhesives can be used.

Cementable TEFLON is now available in tape or sheet form. Tubing, cylinders, rods, and bars made of TEFLON are also obtainable with prepared surfaces.

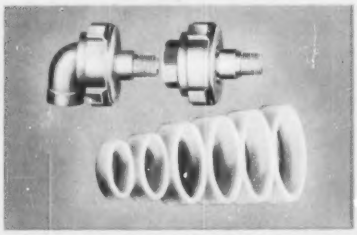
Imaginative applications of Du Pont TEFLON have increased the efficiency of existing equipment. This versatile material provides new design opportunities.

OVER

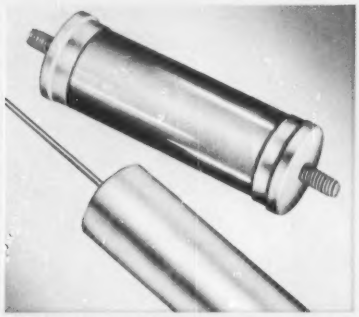
PRODUCT ENGINEERING
DU PONT
PROPERTY AND APPLICATION DATA ON DU PONT "TEFLON" TETRAFLUOROETHYLENE RESIN
NEWS
19
product



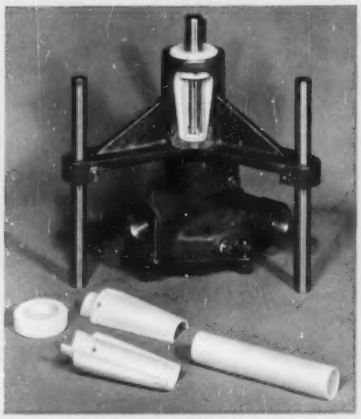
WATER METER PISTON of TEFLON assures accurate meter readings. The low coefficient of friction of TEFLON allows parts to move freely. Because TEFLON is used, no corrosion or build-up takes place in the piston holes or on the periphery to cause errors. (Manufactured by the John L. Doré Company of Houston, Texas.)



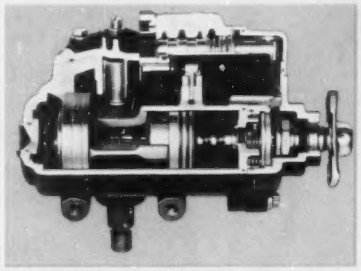
GASKETS for swivel joints employ TEFLON for long wear and trouble-free service. Gaskets maintain their seal under the most adverse conditions. They excel in steam service, perform uniformly over a wide temperature range without requiring lubrication. (Swivel joints by Barco Manufacturing Co., Barrington, Illinois.)



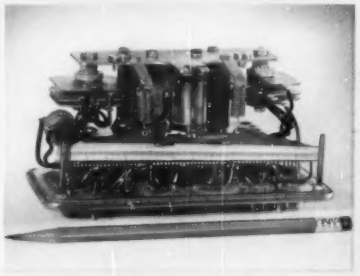
CAPACITORS of TEFLON for use in guided missiles and high-speed aircraft withstand temperature extremes from —90°F to 390°F. The use of TEFLON results in extremely high insulation resistance at rated voltages, and very low power factor at measured frequencies. (Manufactured by Condenser Products Division of New Haven Clock and Watch Company, New Haven, Connecticut.)



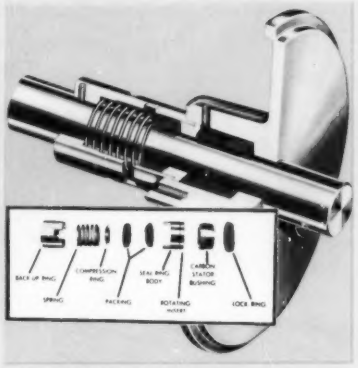
SUMP PUMP for chemicals employs a main bearing of TEFLON, eliminating auxiliary lubrication and the contamination of pumped chemicals by such lubricants. Bearings of TEFLON permit either chemical or steam sterilization, and withstand abrasion and chemical attack. (Manufactured by ECO Engineering Company, Newark, N. J.)



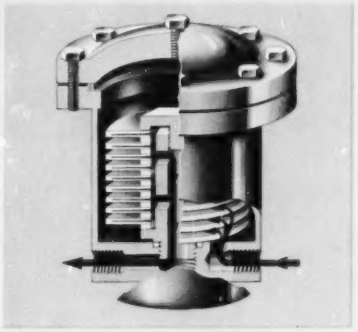
SEALS made of TEFLON reduce manual turning effort and wear in a leading power steering mechanism. TEFLON was selected for its toughness, low coefficient of friction, and exceptional thermal stability. (Seals of TEFLON manufactured by Garlock Packing Company, Palmyra, New York.)



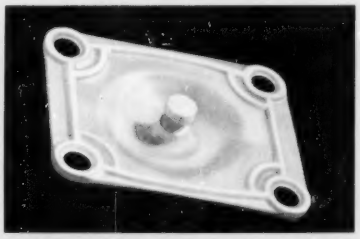
TUBING of Du Pont TEFLON is used as insulation in the compact Size 4 Regohm unit, used for the precise control of current, voltage or speed. TEFLON provides lasting protection, at extremes of temperature and humidity. (Regohm by Electric Regulator Corporation, Norwalk, Connecticut; tubing of TEFLON by Pennsylvania Fluorocarbon Company, Inc., Philadelphia, Pennsylvania.)



MECHANICAL SEAL, in pump for handling corrosive liquids and slurries, utilizes the resiliency and chemical inertness of TEFLON. The use of TEFLON as a shaft packing prevents leakage. TEFLON is also employed as a self-aligning wedge lock, which precludes rotation of the pump stator. (Manufactured by Chemical Power and Products, Inc., New York City, New York.)

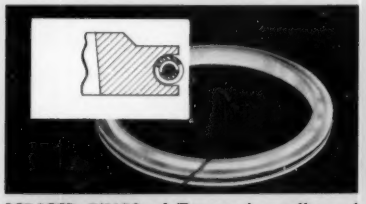


FILTER UNIT of porous TEFLON is a most effective filtration medium, removing particles as small as 3 microns from corrosive liquids, and 0.1 microns from gases. Filters of TEFLON permit high-capacity flow and can be cleaned with solvent. (Manufactured by Porous Plastic Filter Co., Inc., A Pall Filtration Company, Glen Cove, New York.)

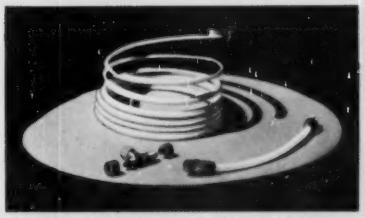


DIAPHRAGMS of TEFLON make it possible to control the flow of extremely corrosive, hard-to-handle fluids. Diaphragm withstands temperatures up to 400°F., or pressures to 100 psi. (Valve manufactured by Hills-McCanna Co., Chicago 18, Illinois; diaphragm of TEFLON molded by Raybestos-Manhattan Inc., Manheim, Pennsylvania.)

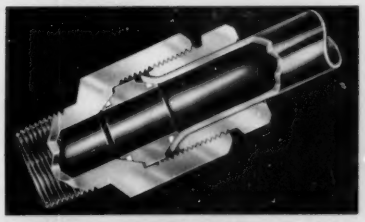
examples of improved design with Du Pont TEFLON®



SCRAPER RINGS of TEFLON keep dirt and other foreign matter away from O-ring seals in hydraulic retracting cylinders and actuators, control valves, and pneumatic equipment. These spring-loaded rings give unexcelled service at high operating temperatures. (Scraper made by Shamban Engineering Company, Culver City, California.)

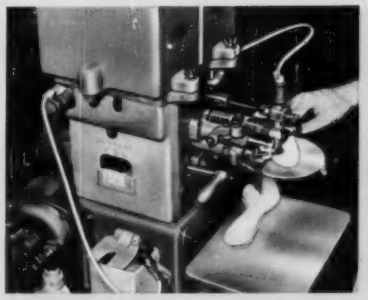


TUBING of TEFLON is exceptionally easy to position or to slide over electrical conductors because of its low coefficient of friction. Convenient to handle, tubings of TEFLON can be readily cut with a knife, bent and positioned by hand. Tubing shown above is manufactured by Halogen Insulator & Seal Corp., Franklin Park, Illinois.

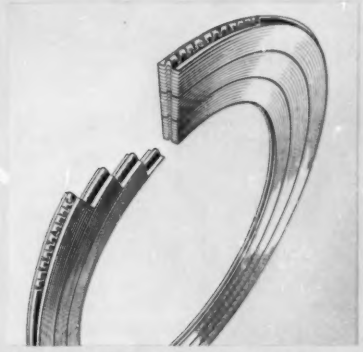


STAINLESS STEEL FITTINGS for flared tubing employ resilient seals of TEFLON which conform to surface irregularities as fittings are tightened. A leak-proof, vacuum-tight seal results, which is resistant to corrosive chemicals. ("Koncentrik" fittings manufactured by Special Screw Products Co., Bedford, Ohio.)

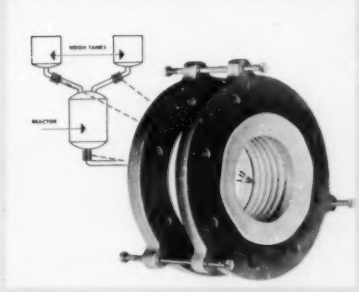
MINIATURIZED COILS show how small electronic components can be made by utilizing the unique electrical and mechanical properties of TEFLON. TEFLON has high volume resistivity, extremely low loss factor, even at very high frequencies, and low dielectric constant. (Wire used in the coils is manufactured by Hitemp Wires, Inc., Mineola, New York.)



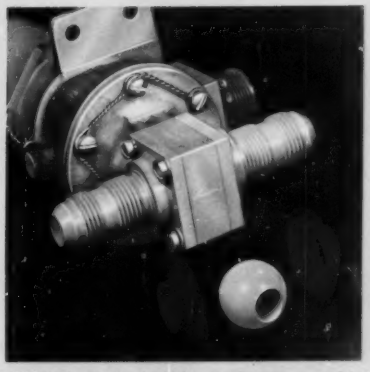
HOSE lined with Du Pont TEFLON is unaffected by the adhesives it handles after three years' use, despite constant flexing. Hose made of TEFLON is now standard equipment for hydraulic, fuel, and other critical lines in jet aircraft and missiles, and is increasingly used to convey corrosives, adhesives, solvents, and superheated steam. (Made by Resistoflex Corporation, Roseland, New Jersey.)



SPIRAL-WOUND GASKETS filled with TEFLON have outstanding corrosion resistance and withstand unusual joint and thermal stresses. Because TEFLON is unaffected by organic solvents and alkalies, longer periods of operation without gasket repair or replacement result. (Manufactured by the Flexitallic Gasket Company, Camden, New Jersey.)

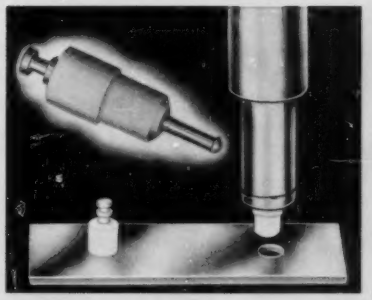


BELLOWS of TEFLON for expansion joints offer flexibility needed to compensate for axial expansion and contraction, and deflection in pipes joining tanks, pumps and reactors. TEFLON absorbs vibration and flexes readily in any direction to safely accommodate pipe movement. (Expansion joint manufactured by United States Gasket Co., Camden, N. J.)



MOLDED BALL SEALS of TEFLON provide tight, long-lasting seals for valves handling hydraulic fluids, water or air. Valve parts of TEFLON have high impact strength, a very low coefficient of friction, no water absorption, and outstanding chemical resistance. (Manufactured by the Sparta Manufacturing Company, Dover, Ohio.)

THIN-WALLED TUBING of TEFLON serves as an insulator around two stainless steel studs in miniature rotary tap switches. Soldering of adjacent connections does not harm insulation of TEFLON, simplifies assembly of switch parts, minimizes accidental grounding. (Manufactured by the Grayhill Company, La Grange, Illinois; tubing supplied by The Polymer Corporation of Pennsylvania, Reading, Pennsylvania, under the trademark *Polypenco.*)



MINIATURE TERMINALS of Du Pont TEFLON tetrafluoroethylene resin are of one-piece construction. The resiliency of TEFLON enables these terminals to be press fit, forming permanent installations having high dielectric strength and heat resistance. ("Press-Fit" terminals manufactured by the Sealectro Corporation, Mamaroneck, New York.)

OVER

DU PONT

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON "TEFLON" TETRAFLUOROETHYLENE RESIN

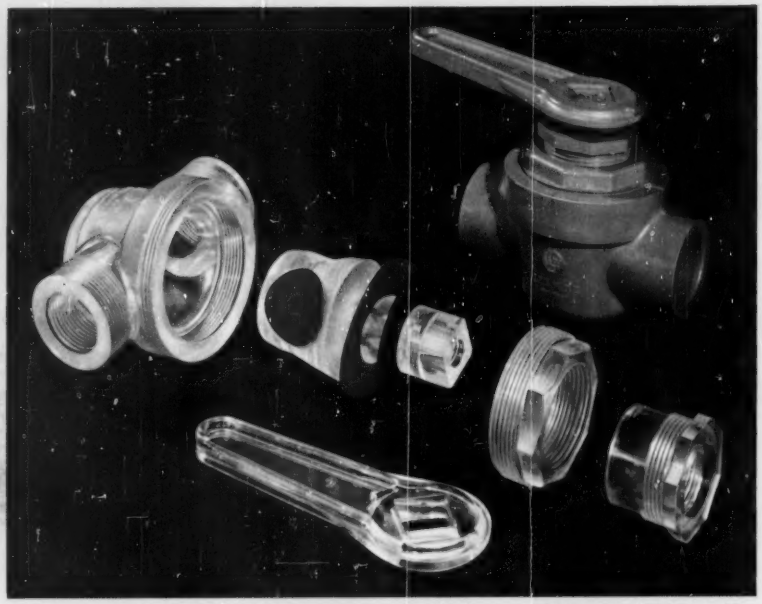
Chemically inert Du Pont TEFLON® requires no lubrication—solves problem in new plug valve

BEARING buttons of TEFLON tetrafluoroethylene resin make this unplasticized pvc plug valve, used in piping corrosive fluids, permanently "self-lubricating". A seal of TEFLON is used on the valve shaft to prevent external leakage. The exceptionally low coefficient of friction of TEFLON ($f = .04$) assures ease of turning and prevents seizing and galling.

The buttons are designed as inserts in the valve spindle. In the closed position, the buttons provide a chemically inert block across the open diameter of the pipe. This valve has been operating for more than a year in concentrated HCl at room temperature. The user reports that no problems of sticking or lubrication have occurred at any time so far.

TEFLON resists all chemicals normally encountered in industry. Exceptions to this include attack by the alkali metals under certain conditions. At elevated temperatures and pressures, halogens and certain halogenated chemicals and solvents may affect TEFLON.

Du Pont TEFLON remains tough over a wide temperature range. It has no water absorption. Sticky or viscous materials do not adhere to its waxy surface. It is specified for electrical uses because of a high dielectric strength and extremely low power factor. The combination of these properties gives TEFLON unique design possibilities in a broad range of applications.



Vital components of Du Pont TEFLON are utilized in this polyvinylchloride plug valve manufactured by Tube Turns Plastics, Inc., Louisville, Kentucky. Exploded view of the valve is based on a transparent mock-up made from Du Pont LUCITE® acrylic resin.

It may pay you to investigate Du Pont TEFLON for use in your own application. For data on this outstanding engineering material, available to you without cost or obligation, clip and mail the coupon at left.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Du Pont Building, Wilmington 98, Delaware. Room 99
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on Du Pont TEFLON tetrafluoroethylene resin. I am interested in evaluating this material for:

NAME_____ POSITION_____

COMPANY_____

STREET_____

CITY_____ STATE_____

TYPE OF BUSINESS_____

TEFLON is a registered trademark...

TEFLON is the registered trademark for Du Pont tetrafluoroethylene resin, and should not be used as an adjective to describe any other product or any component part; nor may this registered trademark be used in whole, or in part, as a trade name for any product.

OILITE
IN AN AUTOMATIC WASHER HELPS BUILD CUSTOMER SATISFACTION -YET COSTS NO MORE
OILITE bronze agitator shaft bearing
OILITE bronze upper center post bearing
OILITE bronze rubber-mounted lower center post bearing
OILITE bronze thrust washers (2)
OILITE bronze pulley bearing
OILITE bronze thrust bearing
OILITE bronze water pump bearing
Photos courtesy Whirlpool-Seeger Corporation St. Joseph, Michigan
Another cost-saving application of Amplex Powder Metallurgy

Quality is a *must* for trouble free operation, continued customer satisfaction. And quality depends upon the excellence of every part, every component. For many years Whirlpool-Seeger has used OILITE center post bearings, agitator shaft bearings, water pump bearings and pulley bearings in their automatic washers. Whirlpool-Seeger uses these and other OILITE parts for very good reasons.

First of all, the manufacturer knows OILITE heavy-duty bronze bearings will meet specifications. Chrysler-Amplex precision production assures him OILITE bearings capable of carrying their loads safely, surely and quietly.

Then too, Chrysler-Amplex plant and facilities—largest and most complete of any in the metal powder fabrication industry—promises on-time deliveries in any quantity.

Moreover, in using OILITE bearings the manufacturer selects a product his customers know and respect for superior engineering.

Finally, this manufacturer, like a great many others, finds OILITE bearings—despite all their advantages—cost no more.

Chrysler-Amplex representatives and dealers are located in principal cities in United States and Canada. Let the nearby representative help you. Find him in the yellow section of your telephone directory under—"Bearings—OILITE."

Representatives and dealers located in principal cities in United States and Canada.

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S-56 ;Standard OILITE Bronze Bearing Stock List. All standard sizes—over 1000 sleeve, flange and thrust bearings, cored, bar and plate stock—are listed in this handy, easy-to-use booklet. Write for your copy today. Address: Dept. 1C, Chrysler-Amplex Division, P.O. Box 2718, Detroit 31, Michigan.

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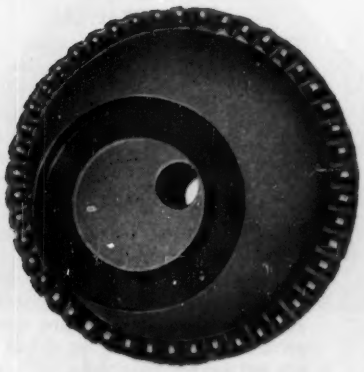
MUELLER BRASS CO. 600 SERIES BRONZE

the main working part in the smooth and OCEAN CITY SPINNING REELS

600 Series gears prove ideal in heavy duty salt water models 300, R300, and 320 in which corrosion resistance and high strength are important.

Other typical "600" applications

FORGED GEAR powerful



The Montague-Ocean City Rod & Reel Co. of Philadelphia is proud of the fact that many fishermen are calling their famous Ocean City "300" series spinning reels "the most dependable spinning reels in America." Such praise justifies the very best components in a product—like the corrosion-resistant Mueller Brass Co. "600" alloy gear. Provides its own shaft and has an integral clutch which takes the driving force from the handle, and incorporates a cam which provides the oscillating motion of the spool for cross-winding the line. Bronze was chosen because of the need for maximum strength, long wear, and because it is such an excellent bearing material. This application dramatically points up the valuable properties of Mueller "600" series alloys.

There are countless applications of Mueller "600" series bearing alloys. Find out how you can utilize one or more of them in YOUR products. Because forgings can be made closer to the finish size in "600" series alloys than can sand castings, there is less waste, greater speed in finishing.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐

600 Series Bearing Alloys Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

METALS AND ALLOY REVIEW

by FRANK M. LEVY

Vice-President and Director of Research

Recently Ray Engelgau, who heads our statistical quality control procedures, and Amos Armitage from our machining department met in my office and we had a very interesting discussion on our new "S-C" rod. The term "S-C" is derived from the fact that it is produced from billets that are cast semi-continuously. In addition, we use the letters "S-C" to indicate its "super cutting" qualities which is one of the outstanding characteristics of this rod. We have definitely proved these qualities in some very exhaustive tests, one of which I'd like to tell you about here.

Experience has shown that it is difficult to control dimensions within close tolerances on machine parts involving internal forming operations. Amos had run into exactly that trouble with a certain hydraulic fitting made from rod that required a fairly close dimensional tolerance on the internal formed diameter. So, we decided to make a comparison test by machining the part from rod made by the conventional method and from rod produced by the S-C process. When rod made by the conventional method was machined, the parts could not be held within the specified tolerance range. The same machine, the same tooling and the same machine operator were used in this test, and when S-C process rod was substituted, the machine parts were well within the required tolerance range.

In addition, I just received a letter from a well-known equipment manufacturer who has been running tests on S-C rod. They reported that the incidence of tool trouble per 1000 forgings machined from S-C rod were approximately half that of forgings made from conventional rod. We think that is pretty good evidence that the rod made by our semi-continuous process is exceptionally uniform by all standards. Incidentally, our new billet casting department is quite a model of automation and has a number of interesting processes and features. Anytime you happen to be in our area we would be more than happy to show you through and explain the many points of this process that gives us what we firmly believe to be the best possible rod available today which of course is reflected in the quality of our forgings.

If you would like a folder that fully covers our semi-continuous process, just drop me a note and I'll see that one is sent along to you promptly. In the meantime, we'd like to have you investigate our super-cutting S-C rod because we think it will improve your product quality—and we've got the alloys to do most anything to meet the most exacting demands.

Thanks for your time.

MUELLER BRASS CO.

PORT HURON 20, MICHIGAN

199

(Advertisement)

Know your timer types...

Grouping the multiplicity of timer types into four broad classes simplifies equipment designer's job:

INTERVAL TIMERS

The first—and simplest—group is that of the interval timers. These consist basically of a motor, an arm or cam, and a switch. To operate the timer, the user simply sets the mechanism manually to the desired time interval. This action transfers switch contacts that start the timer motor.

The motor drives the timer mechanism to the end of the timing cycle. At this point the switch returns to its original position and the motor shuts off.

A variety of dials, knobs, push-

INTERVAL TIMER of advanced design, the new Cramer Type 241 features large easy-to-read dial, pushbutton start, automatic and immediate reset and repeat accuracy of ± ¼ of 1% of full scale. Bulletin PB-241.

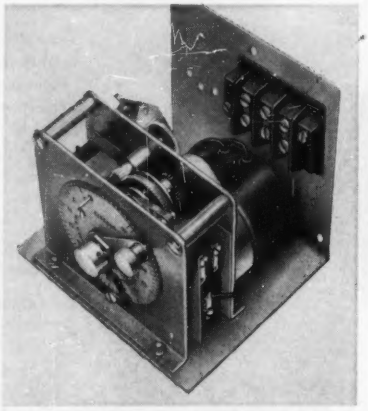
button start, automatic reset features, special housings and additional load switches may be used, but the basic operation is the same. Interval timers are used in applications that require frequent changes in setting—like photographic exposure timing.

TIME DELAY RELAYS

The time delay relay represents the second large group of timing devices. These units provide accurately timed delays between the closing of an external remote switch and the transfer of a load switch. At the end of each cycle, the motor shuts off automatically, and the standard device remains in this "timed out" condition until the clutch is released allowing the timer to reset. Other variations reset automatically at the end of a cycle. Models are available to either reset on power failure or suspend operation until the circuit is restored.

Special housings, additional switches, various clutching mechanisms, and a wide selection of wiring arrangements make the time delay relay an extremely versatile device.

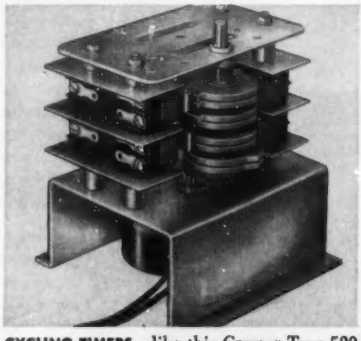
A typical application is for regulating processes such as heat treating where the timer controls the amount of time required to produce the desired change in the metal.



TIME DELAY RELAYS—like the Cramer Type 440A above—are rugged, dependable and accurate devices to control from 1 to 5 load circuits. For flush, surface or panel mounting. Bulletins PB-310 and PB-311.

CYCLING TIMERS

In the third category are found the cycling timers. Fundamentally these units are made up of the driving motor, a cam (or arm) which is revolved continually by the motor, and a switch operated by the cam. The cycling timer produces switch transfer repeatedly, according to the cam cuts, as long as the motor runs.

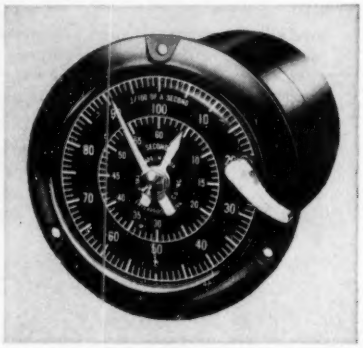


CYCLING TIMERS—like this Cramer Type 520 come in 1 to 8 poles. Normally factory preset for highest accuracy. Operating speeds 1 rev./6 sec. to 1 rev./day. Bulletin PB-510A.

Variations of the cycle timer include changing the motor speed, cutting cams in an almost infinite number of combinations, and adding switches. The cam setting may be fixed or adjustable. Special housings are available. Cycle timers are used to control a program or sequence of events as in a signaling system.

TIME TOTALIZERS

Time totalizers, or elapsed time indicators, range in complexity from a simple motor-driven counter to the precision time totalizer used in scientific research. The former, usually used as a running time meter, counts discrete time *units* from tenths of a second to hours. The more elaborate time totalizer is actually an electrical stop clock capable of measuring time intervals to an accuracy of ± 0.01 second. Running time meters are used to record the operating or down time of industrial machines. They are offered in many models—with or without reset, in portable or die-cast enclosures, etc. Time totalizers are commonly applied in test equipment for industrial and military laboratories.



TIME TOTALIZER of laboratory quality. The Cramer Type 690 features easy-to-read scale and pointers for fast, exact readings, accuracy to ± 0.01 second. Reset lever conveniently located on dial face. Bulletin PB-610.

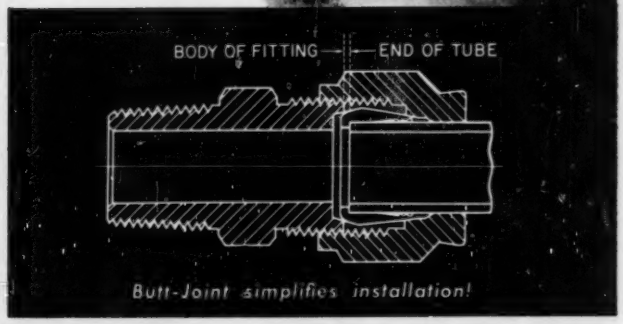
LEARN MORE about these four basic timer types from Cramer's complete line. Just ask us to send you our bulletins on the types that interest you. Nearly 100 varieties are *stocked* for immediate shipment. Cramer Controls Corporation, Box 6, Centerbrook, Connecticut. (Formerly R.W. Cramer Co.) 7.1

TALK IT OVER WITH

CRAMER CONTROLS
CORPORATION

Circle 430 on page 19

the most important advance in tube fittings in 20 years!



New IMPERIAL HI-SEAL™

Furnished in steel and stainless steel

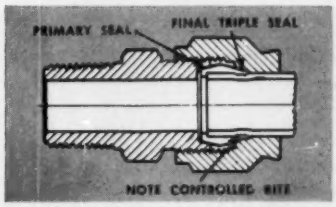
makes a positive butt-joint • no need to spring tubing • withstands higher pressures • foolproof assembly • no flaring or threading

Hi-Seal is the successor to all present tube fittings for high-pressure, severe service. Never before such ease in making a truly foolproof tubing connection. Sleeve fits only *one* way, cannot be installed in reverse — no chance for error. Positive butt-joint with no tube entry into body of fitting eliminates need to spring tubing. This is especially important when working with large-diameter, heavy-wall or hard-temper tubing. Positively no torquing of tube when making a joint!

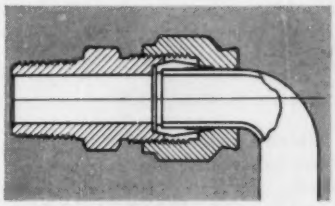
All this plus the fact that Hi-Seal fittings can be disconnected and reconnected as often as desired with assurance of original pressure-tight seal!

Conforms to **J.I.C.** Standards

Ask your Imperial distributor for full details on the Hi-Seal Fitting. Write for Bulletin 3061.



FOOLPROOF ASSEMBLY—Hi-Seal goes together only one way. No need to disassemble or double check for tightness.



CLOSER TUBE BENDS — works in close quarters where other types of fittings cannot be used. A real aid to design.

WITHSTANDS HIGHER PRESSURES—Joints stay tight beyond the burst pressure of the tube . . thoroughly field tested.

Created and manufactured exclusively by . . .

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IMPERIAL

Industry's most complete line of tube fittings and tubing tools.

DESIGNER'S FAVORITE SENSITIVE, VERY RESPONSIVE

Thermoswitch® Is Rugged, Adaptable, Heat Controller

ASHLAND, MASS. — Word emanating from here is that Fenwal Incorporated's THERMOSWITCH units are usually the best solution for a design engineer with temperature-control problems.

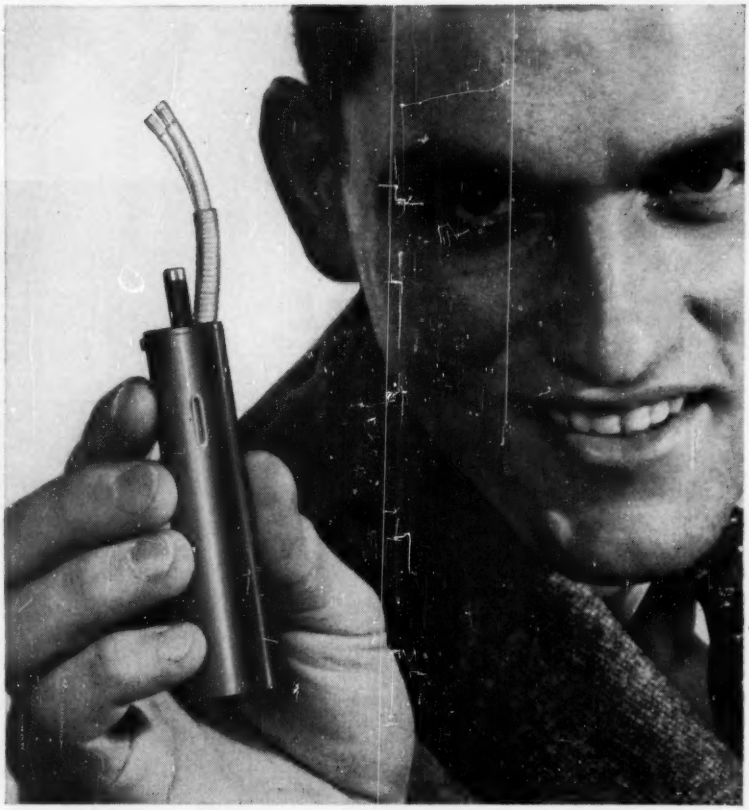
THERMOSWITCH thermal controls are adaptable, sensitive, responsive, small, tough, and accurate — and their price is right. They frequently replace controllers costing much more, and do a better job.

Their principle of operation is unique — and highly competitive in terms of every quality most design engineers would require. The unique principle is this: *the activating control element is a single-metal shell that expands or contracts instantaneously with temperature changes, making or breaking the totally-enclosed electrical contacts.*

Design engineers have put THERMOSWITCH units to work everywhere that temperature control is vital — in planes . . . factories . . . ships . . . hospitals . . . food-processing plants . . . homes . . . laboratories. The list of THERMOSWITCH applications is virtually endless. So is the list of physical ordeals the units have survived and the high performance standards they've met.

When tested alongside bulb-type and enclosed bi-metallic thermostats under identical conditions, THERMOSWITCH units have overwhelmed both with performances like these:

- reaction speed, four to nine times as fast;
- heat-responsive area, three to six times as large;
- heat-transfer path, only one-third to one-sixth as long;
- temperature differential, only one-tenth to one-nineteenth as great;
- vibration-sensitivity, only one-twelfth to one-eighteenth as great;
- shock-sensitivity, only one-tenth to one-eighteenth as great;



FENWAL THERMOSWITCH UNITS may solve your temperature control problems, too. Sensitive, tough, and accurate — they have been put to work by designers wherever temperature control is vital. Over 25,000 variations of the THERMOSWITCH unit are available. Write for THERMOSWITCH folder.

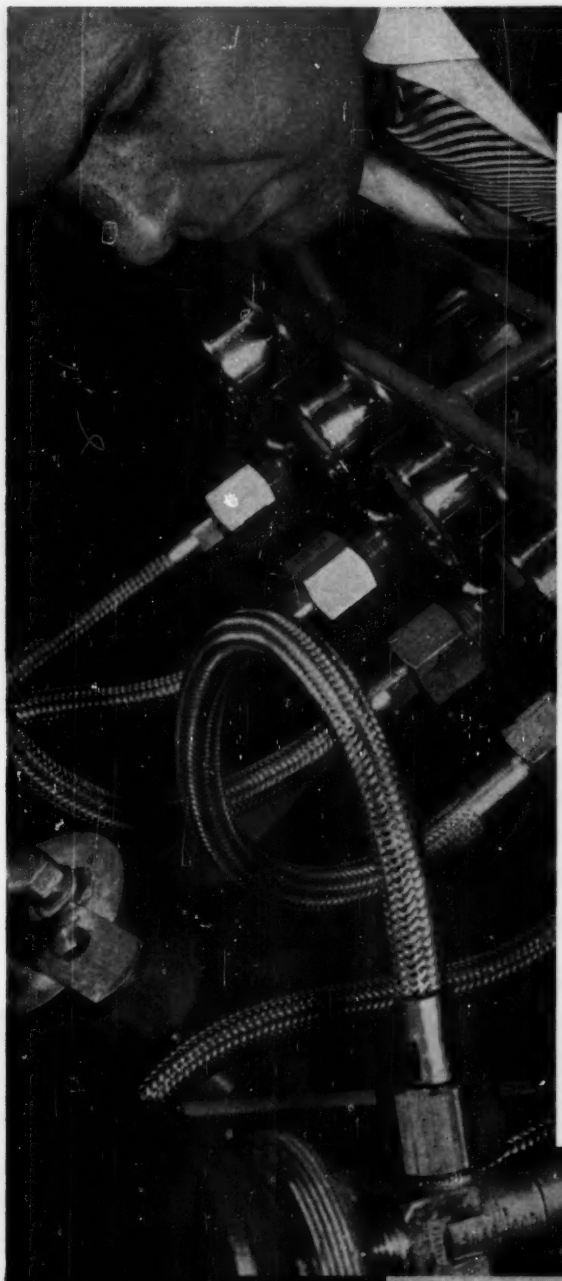
Added to these points of superiority are such demonstrable features as uniformity of sensitivity throughout the operating range, built-in temperature anticipation, enclosed tamper-proof assembly, direct radiant heat reception, and an operating range from −100°F. to 600°F.

Other ranges are available, too. The point at which a unit makes or breaks a circuit is determined by a set screw easily adjusted in the field.

There's a Fenwal sales engineer ready to help you apply THERMOSWITCH units to your particular heat control problems — ready with over 25,000 variations. Write Fenwal for his name and for complete specifications. **Fenwal Incorporated, 191 Pleasant Street, Ashland, Mass.**

Fenwal

CONTROLS TEMPERATURE . . . *PRECISELY*



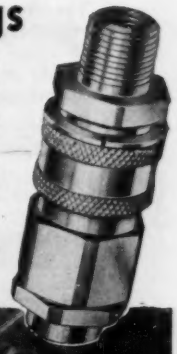
Now...Local Availability on

Titeflex
Flexible Metal Hose

for conveying "Problem" Liquids and Gases!

Titeflex Hose solves scores of problems in conveying organic and volatile liquids as well as corrosive gases. Connects moving and/or misaligned machine parts, other terminal joints. Withstands high extremes in temperature, pressure. Absorbs vibration, shock, and flexing . . . with ease. Sizes 3/16" to 3" Other tough conveyance problems are solved with Titeflex flexible hose made of TEFLON* in sizes of 1/4" to 1 1/4".

Titeflex
Quick-Seal Couplings

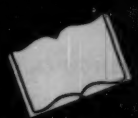


—the ideal "connecting mate" for Titeflex Hose or *any other kind of quality hose.* Connects or disconnects in ONE second and . . . the higher the pressure the tighter the seal!

Both these time-tested products are available for immediate shipment from distributors' stocks in most areas. Otherwise write, wire, or telephone direct.

*Du Pont trademark for its tetrafluoroethylene resin

CALL YOUR LOCAL DISTRIBUTOR



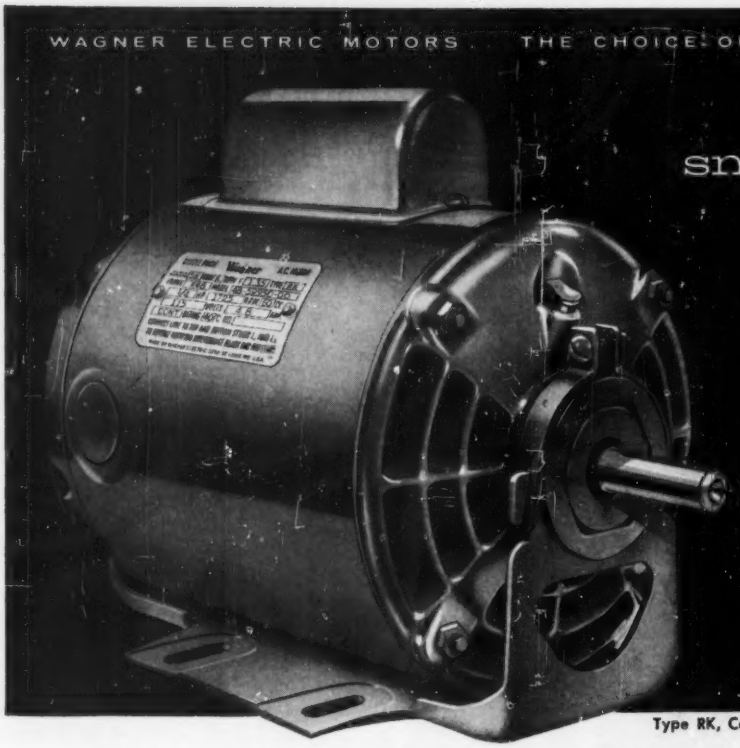
Consult the yellow pages of your telephone directory

Your one source for both Hose and Couplings

Titeflex

TITEFLEX, INC., 508 HENDEE STREET, SPRINGFIELD 4, MASS.

WAGNER ELECTRIC MOTORS THE CHOICE OF LEADERS IN INDUSTRY



smaller, lighter fractional horsepower motor solves problems for the design engineer

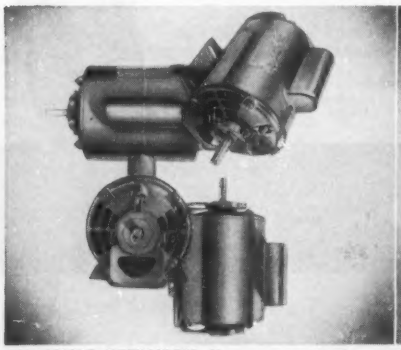
Type RK, Capacitor-start, 1/6, or 1/4 hp.

the WAGNER "48"

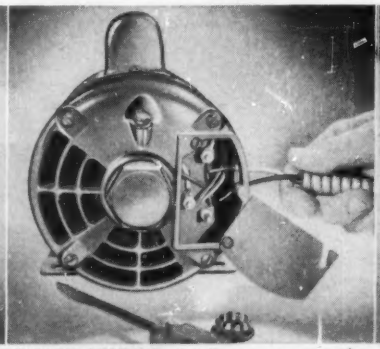
Here's the 48 frame motor you've been looking for! The Wagner "48" capacitor-start motor with either resilient or welded rigid base. You get the standard 48 frame size, with from *three to eight pounds less weight per motor* than previous models of the same hp ratings!

The Wagner "48" is rugged enough to permit direct mounting, compact enough to fit in tight spots, will operate efficiently when mounted at any angle. Through ventilation assures cool operation that adds to motor life.

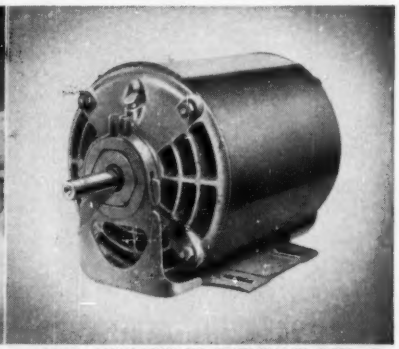
If you would like to test the Wagner "48", one of our field engineers will be glad to furnish a sample motor. Contact the Wagner Branch near you or write to the factory.



ALL ANGLE OPERATION. You can mount the Wagner "48" at any angle. A new lubrication system assures positive protective lubrication in any position.



EASY TO CONNECT. Just loosen one screw for access to terminal board. EASY TO SERVICE . . . no need to disconnect leads when removing endplates.



ALSO AVAILABLE IN SPLIT-PHASE TYPE. The Wagner "48" is also furnished in split-phase type, with resilient or rigid base in ratings of 1/6, 1/4 and 1/3 hp.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

H57-2

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

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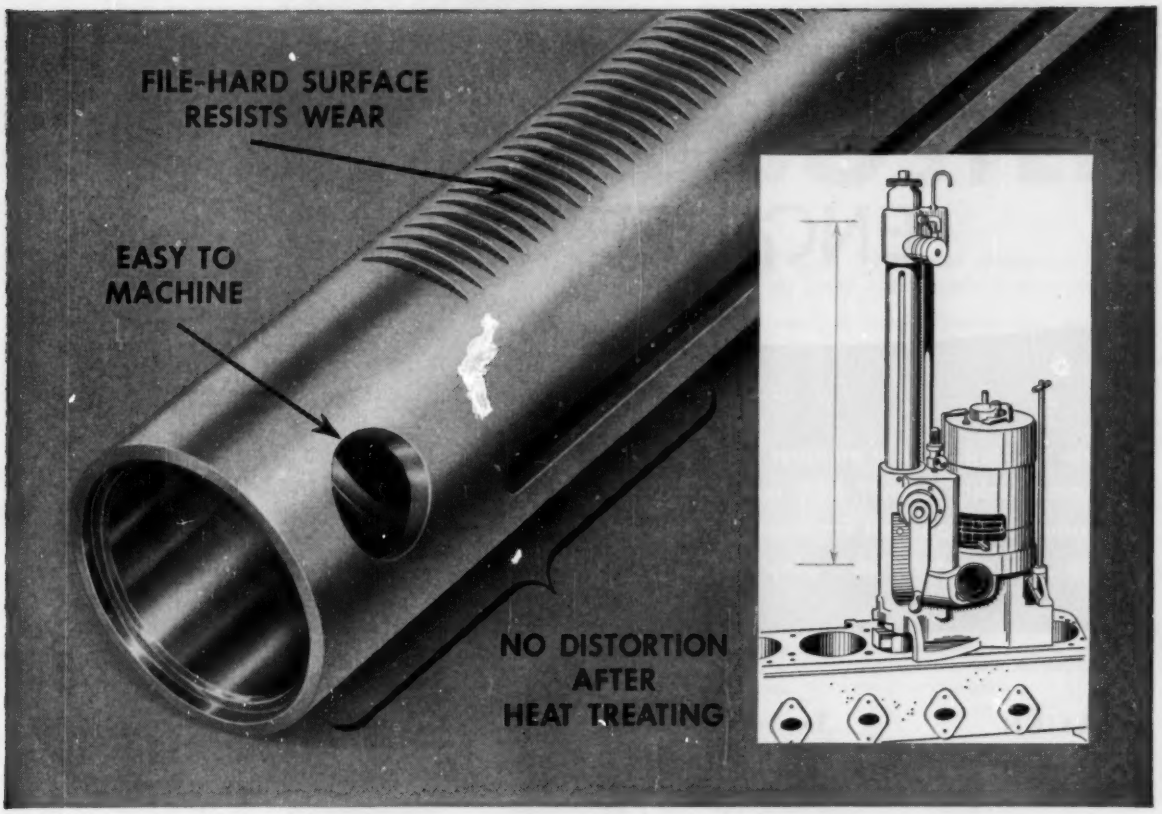
6404 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC



Boring bar maker solves heat-treat distortion problem by switching to TIMKEN® 52100 steel

HEAT-TREATING distortion was running up the manufacturing costs of the boring bars Van Norman Automotive Equipment Company makes for reboring hard-sleeve cylinder blocks. The column of the boring bar, which acts as the spindle, had to be extremely straight. Yet many of them were distorting after heat treatment. And that meant putting them through an extra straightening process.

Studying the problem, metallurgists of the Timken Company suggested a switch to Timken® 52100 steel. Since this steel is hard and tough, it had the qualities Van Norman wanted. And because it responds uniformly to heat treatment it proved to be the answer to their production problem.

By switching to Timken 52100 steel, Van Norman eliminated the need for the costly straightening operation. And as a bonus, they've found that Timken 52100 steel is easier to machine than the steel they previously used.

The Timken Company pioneered the development of 52100 and is one of the principal producers of the steel—the only source of the grade in three finished forms: bars, tubing and wire. You can rely on the Timken Company for small run or emergency requirements as well as mill quantities.

We stock 101 sizes of 52100 steel tubing, ranging from 1″ to 10½″ O.D. For a complete stock list of available sizes, grades and finishes, write The Timken Roller Bearing Company, Canton 6, Ohio. Cable: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Circle 435 on page 19

MECHANICAL ENGINEERS

DESIGN

DEVELOPMENT

PRODUCTION

Ever wanted to be a member of a real championship team?? As a member of the Product Development Engineering Department your "team play" will include:

DESIGN

You create basic design concepts based on practical means of accomplishment. Your concepts are translated by layout draftsmen to a more communicable form under your guidance. In other words, HOW, WHAT, WHY, WHERE systemized.

DEVELOPMENT

You evaluate, refine and improve; using the finest PRODUCT IMPROVEMENT TOOLS. These "TOOLS" include the best TEST and RESEARCH facilities available and you have the added advantage of working alongside the top men in this field.

PRODUCTION

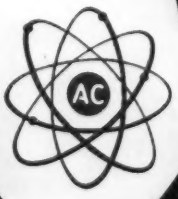
You supervise the evolution of a production model based upon engineering prototypes resulting from the Design and Development. Produceability and a high degree of reliability will be your responsibility. Your job will include the maintainability and function of Electro-Mechanical Devices, Precision Gear Trains and Packaged Electronics in the fields of Inertial Guidance, Avionics and Jet Engine Fuel Controls.

Job assignments are accomplished by men operating as a team. Our program is expanding and Challenging Opportunities await qualified men for important positions on our Engineering teams. Why not you??
As a part of our Major, Permanent, Company Expansion Program, new plant facilities are being added in suburban Milwaukee.

RECENT ME GRADUATE INQUIRIES ALSO INVITED

Milwaukee offers ideal family living in a progressive, neighborly community combining cultural and shopping advantages with small town hospitality. You and your family will love Milwaukee.
To arrange personal, confidential interview in your locality send résumé today to

Mr. John F. Heffinger
Supervisor of Technical Employment



the ELECTRONICS DIVISION

GENERAL MOTORS CORP.

FLINT 2, MICHIGAN • MILWAUKEE 2, WISCONSIN

Circle 436 on page 19

Miller

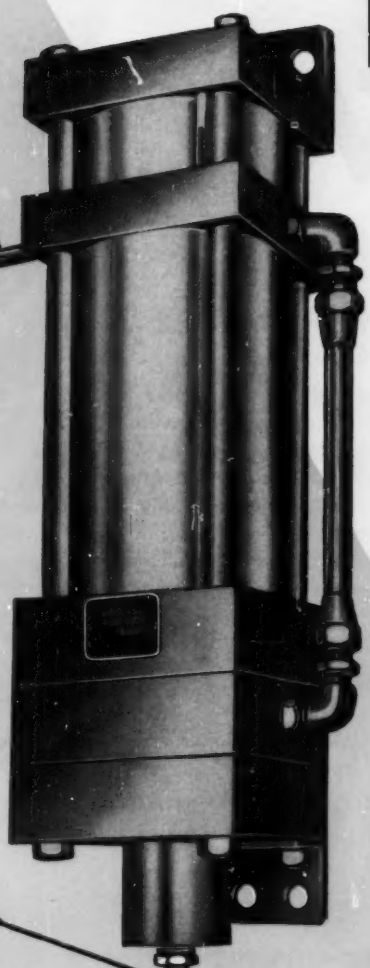
FLUID PRESSURE BOOSTERS

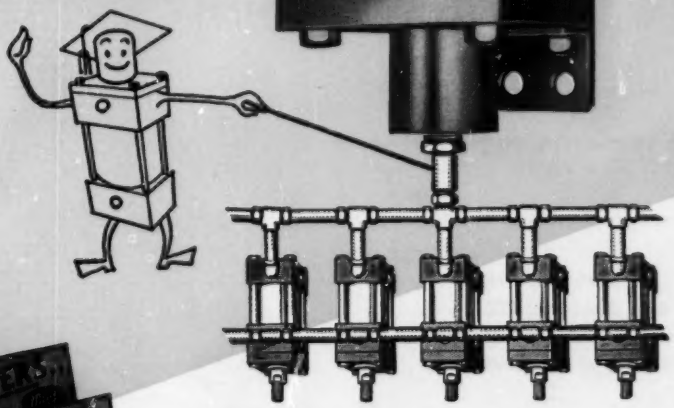
BOOST 80 PSI AIR

Input Range: 40 to 3000 psi Air or Fluid

TO 2000 PSI HYDRAULIC PRESSURE

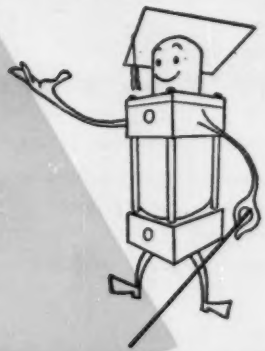
Output Range: 200 to 10,000 psi Fluid





- Save space, weight and investment cost by replacing pump installations in many applications.
- Less costly to install, operate and maintain.
- **Hold Pressure indefinitely** without the motion and heat generation of ordinary pump circuits.
- Provide—at point of cylinder thrust—more efficient power with less weight in less space than direct driven air cylinders
- Save up to 95% of air consumed by direct driven air cylinders
- Operate at speeds of 30 to 450 strokes per minute.

NOTE: In addition to its most complete line of "Custom-Built" Boosters available on normal delivery Miller offers 5" bore, 25 to 1 ratio, boosters for immediate delivery in either 6" or 12" stroke. Write for data and prices.



ESPECIALLY RECOMMENDED FOR

- **WELDING**
- **PUNCHING**
- **SHEARING**
- **CLAMPING**
- **RIVETING**
- **CRIMPING**
- **PRESSING**

and similar applications

FULL DETAILS IN MILLER BULLETIN B-200 SENT FREE ON REQUEST
Other Miller products include: Air cylinders, 1½" to 20" Bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

SALES AND SERVICE FROM COAST TO COAST

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Miller

MILLER FLUID POWER DIVISION FLICK-REEDY CORP.

2006 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

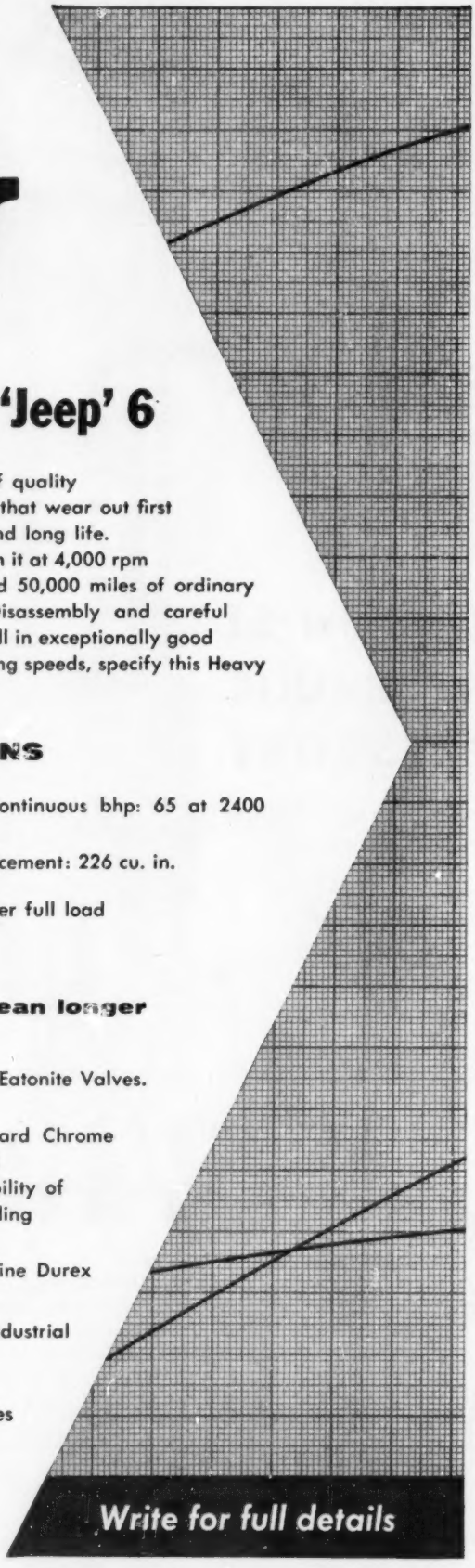
Circle 437 on page 19

STAMINA such as you've never seen before!

NEW

HIGH TORQUE HEAVY DUTY 'Jeep' 6

This new Keypoint Engineered engine sets a new standard of quality design in the industrial engine field. Extra durability for parts that wear out first in ordinary engines results in full-time 'Jeep' dependability and long life. To prove this engine's ruggedness in action, Willys engineers ran it at 4,000 rpm under full load in repeated 100-hour tests. Each test simulated 50,000 miles of ordinary vehicle travel. Breakdowns: None. Parts failures: None. Disassembly and careful inspection after all tests revealed that every component was still in exceptionally good condition! For real stamina . . . for high torque at low operating speeds, specify this Heavy Duty 'Jeep' 6.



HEAVY DUTY 'Jeep' 6 SPECIFICATIONS

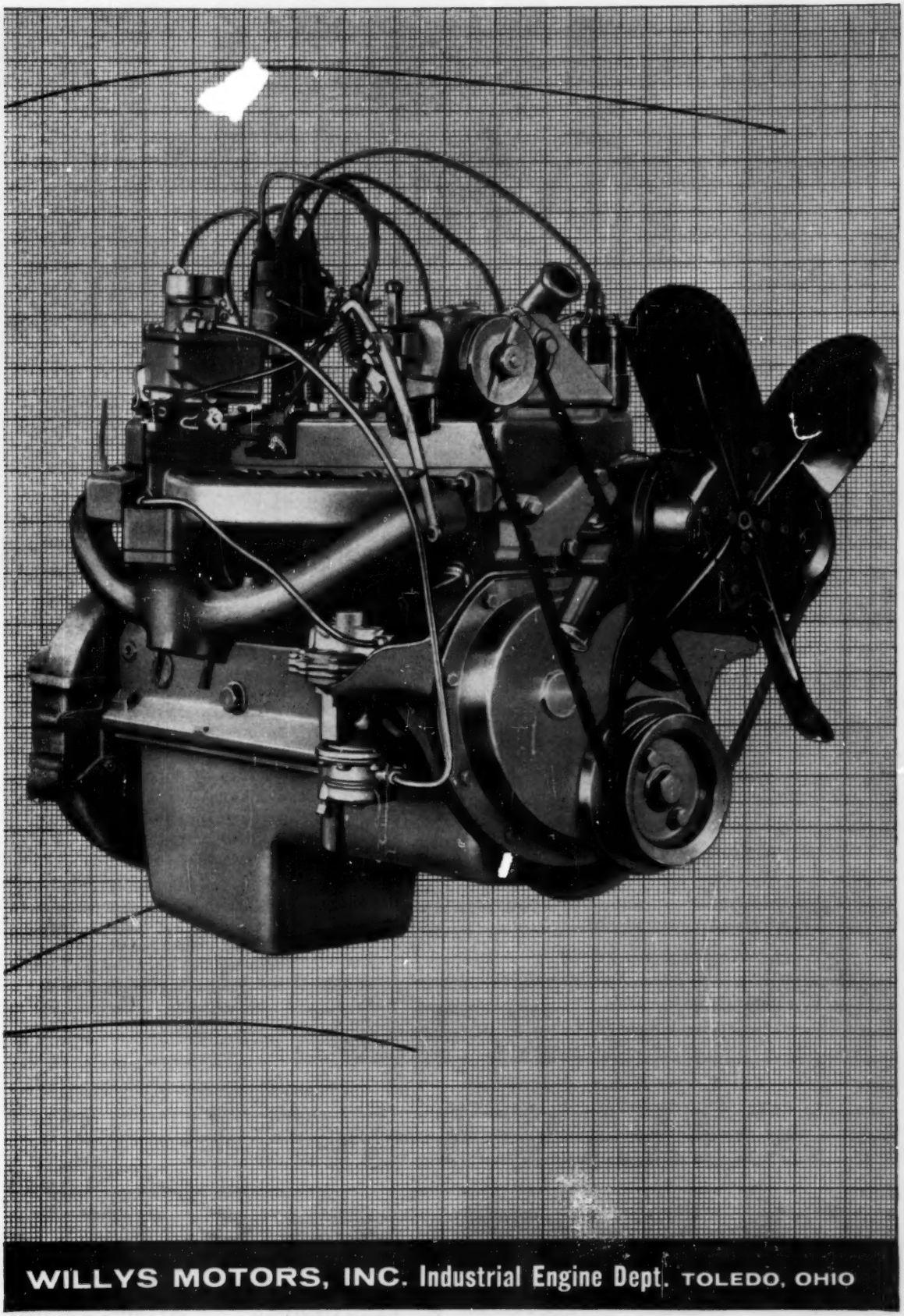
- Maximum Torque: 180 ft. lbs.*
- Maximum Continuous Torque: 142 ft. lbs.* (torque peaks at 1200 rpm)
- Maximum bhp: 92 at 3200 rpm*
- Maximum Continuous bhp: 65 at 2400 rpm*
- Piston Displacement: 226 cu. in.

*All tests under full load

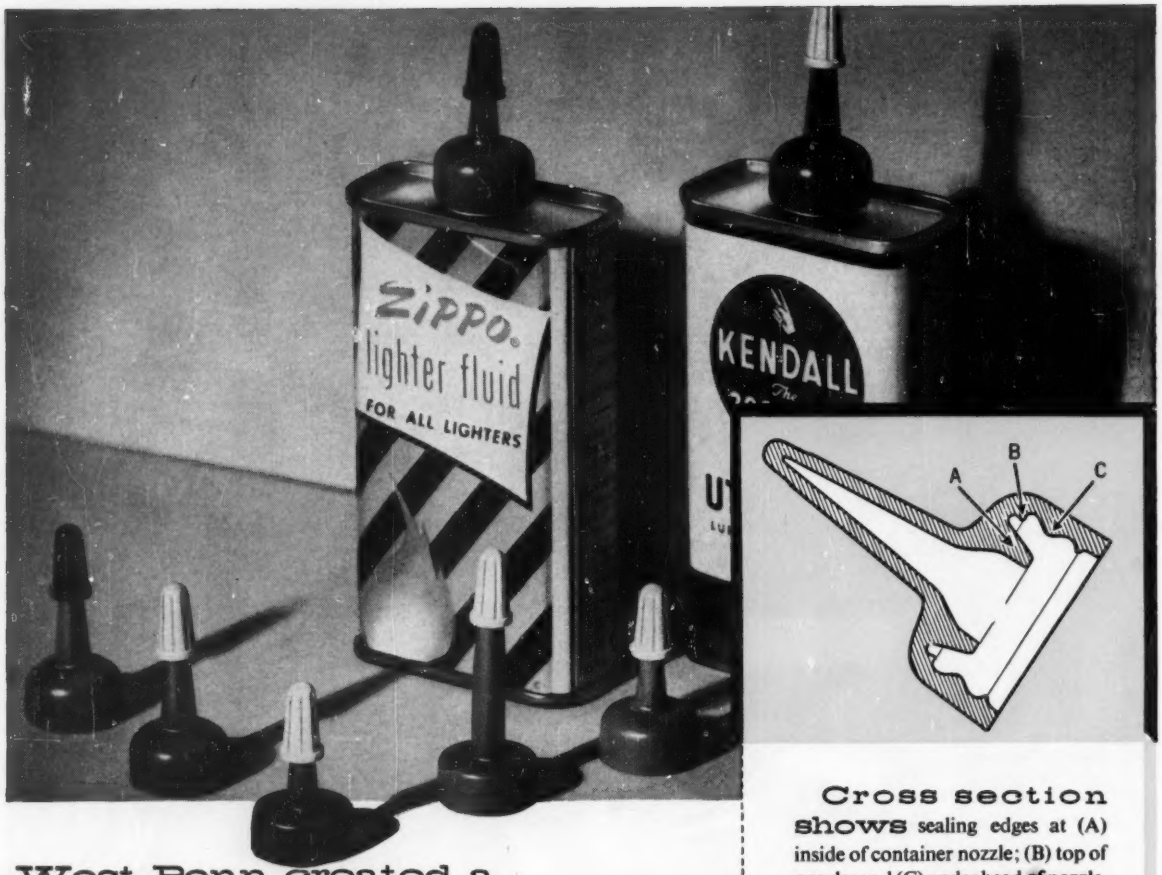
These KEYPOINT-ENGINEERED features mean longer engine life, low-cost upkeep

- **POSITIVE VALVE ROTATORS.** Hard Face Stellite or Eatonite Valves. Stellite or Eatonite Valve Inserts.
- **FOUR RING ALUMINUM ALLOY PISTONS** with Hard Chrome Compression Ring and Hard Chrome Steel Rail Oil Ring. New Piston Control Band reduces the possibility of slap and skirt collapse and contributes to outstanding oil economy.
- **NEW PREMIUM HEAVY DUTY BEARINGS** of Moraine Durex
- **FORGED CRANKSHAFT.** 100% counterweighted.
- **HIGH TORQUE CAMSHAFT** specially designed for industrial use provides extra lugging power at low operating speeds.
- **SINGLE CARBURETION AND MANIFOLDING** provides maximum efficiency from every drop of fuel.

Write for full details



Circle 438 on page 19



West Penn created a leakproof closure ...Sylvania custom-molded it

LIGHTER FLUID, oil and other penetrating liquids, to be effectively packaged, call for a container closure with an extremely tight seal.

Custom molding of intricate parts like this is just one of the reasons leading manufacturers, large and small, come to Sylvania for consultation on parts designs.

Sylvania's Parts Division offers complete facilities for custom metal stampings, special electronic components and special wires. For complete details of these services, write for the "Portfolio of 4-way Service to Designers."

Cross section shows sealing edges at (A) inside of container nozzle; (B) top of nozzle; and (C) under bead of nozzle. Closure also seats deeply in mouth, to further prevent leakage.

West Penn Closure Corp., Warren, Pennsylvania, wanted a leakproof seal that could be easily applied by high-speed machinery . . . serve as a dispenser as well as stopper . . . and be practically indestructible.

They found the answer in a polyethylene spout with three different sealing edges, and a self-threading urea cap which formed a tight, yet easily removed top. And they found that Sylvania could hold their required tolerances and produce them in high volume.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS · 4-way service from one source

LIGHTING • RADIO • TELEVISION • ELECTRONICS • ATOMIC ENERGY

Circle 439 on page 19

ATTEND the 1st ENGINEERED CASTINGS SHOW

. . . and Learn **HOW** *to Design for*

UTILITY
QUALITY
ECONOMY

CINCINNATI
MUSIC HALL
MAY 6-10, 1957

To keep ahead of competition, SEE why CASTINGS . . . shortest distance between raw materials and finished products . . . can be adapted to every design-engineering requirement.

Product-Design Engineers and Users of Cast Products are invited to attend THE ENGINEERED CASTINGS SHOW, the first industrial exposition of its kind in America, where the inherent utility of Castings will be demonstrated in terms of design, material and methods.

Under one roof . . . ready for side-by-side comparison . . . will be the greatest assembly of engineered castings ever displayed. Here, Product-Design Engineers will meet with Castings Producers to discuss and observe the engineering effectiveness of Modern Castings, Patterns, Testing Devices and Metals essential to production of Quality Castings.

Supplementing the panorama of engineered castings will be a special program of papers, directly relating to the interests of Castings Designers and Users.

A 5-day event . . . designed to demonstrate the unlimited application of modern castings to all engineered structures . . . THE ENGINEERED CASTINGS SHOW is a "must" for all Product-Design Engineers and users of castings.

CASTINGS PENETRATE ALL FIELDS OF MANUFACTURE

Agricultural Equipment
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Aircraft
Automotive
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Brewing and Distilling
Business Machines
Canning
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Chemical Processing Machinery
Construction
Dairy Products Machinery
Electrical
Food Processing
Heating
Hydraulic & Pneumatic Equipment
Laundry
Leather Working
Lumber and Saw Mill Machinery
Machine Tools
Marine
Materials Handling
Metalworking
Military Equipment
Mining
Nuclear Science Equipment
Ordnance
Packaging
Paint Making Machinery
Paper Making
Petroleum Equipment
Photographic Equipment
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Textile Machinery
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Waterworks Equipment
Woodworking Equipment

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AMERICAN FOUNDRYMEN'S SOCIETY
GOLF AND WOLF ROADS
DES PLAINES, ILLINOIS

Yes! I plan to attend THE 1st ENGINEERED CASTINGS SHOW. Send me tentative program, registration cards and regular meeting notices.

NAME_____

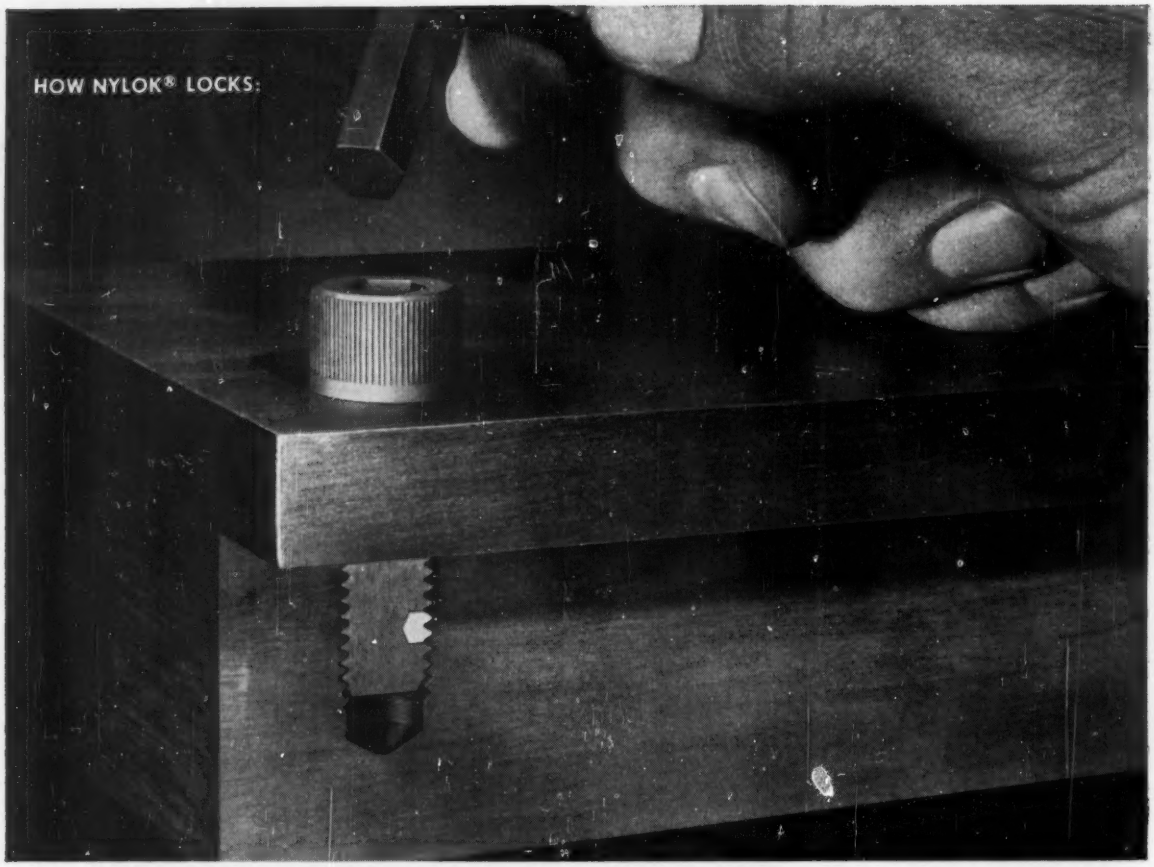
TITLE_____

COMPANY_____

ADDRESS_____

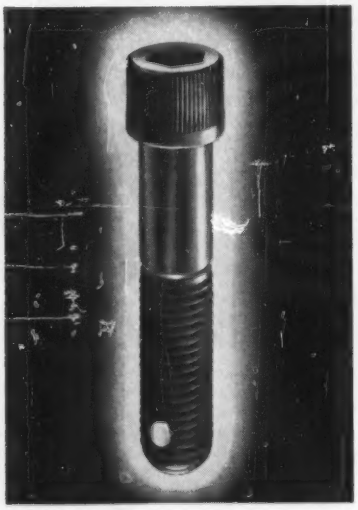
CITY_____ ZONE____ STATE_____

Circle 440 on page 19



LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together and locks the screw securely.

NEW—self-locking UNBRAKO socket head cap screws



Self-locking UNBRAKO socket head cap screw.

They won't work loose. And they simplify design and save production time.

UNBRAKO socket head cap screws are now available embodying the Nylok* self-locking principle. Nylok provides the first truly practical solution to the problem of making cap screws self-locking.

An UNBRAKO cap screw with Nylok is a single self-locking unit. No auxiliary locking devices are needed. Just thread the UNBRAKO into any tapped hole. *Seated or not*, it locks positively wherever wrenching stops. The tough, resilient nylon pellet forces mating threads together and holds tight. The screw will not work loose.

You save production time when you make products with self-locking UNBRAKOS. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. And in many cases you will save weight and mass by using shorter screws in tapped holes instead of drilling through and using nuts and lockwashers.

Self-locking UNBRAKOS are reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, when screws are properly seated, the locking pellet also functions as a liquid seal.

A complete line of self-locking UNBRAKO socket screw products, in a wide range of standard sizes, materials and finishes, is available through your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

T.M. Reg. U.S. Pat. Off., The Nylok Corporation

STANDARD PRESSED STEEL CO.

UNBRAKO SOCKET SCREW DIVISION

SPS

JENKINTOWN PENNSYLVANIA

Circle 441 on page 19

Circle 442 on page 19→

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 34

Silastic Eliminates Slippage On Oscillograph Feed Rolls

The ability of Silastic*, Dow Corning's silicone rubber, to retain uniform resiliency from —130 to 500 F aids our development of natural resources by increasing the reliability of oil-finding instruments.

Seismic impulses created by detonating explosive charges underground are picked up by seismometers, amplified, and recorded by oscillographs on moving rolls of photographic paper. To obtain truly accurate readings, it is essential that the paper, fed by rubber surfaced drive rollers, move at a constant rate of speed.

Feed rolls coated with organic rubber hampered the accuracy of readings because the rubber hardens when exposed to low temperatures. The resultant changes in friction between rolls and paper caused varying degrees of slippage.

Atlantic Refining Company of Dallas, Texas, solved the problem by surfacing the feed rolls with Silastic, the silicone rubber that shows little or no change in hardness over a wide temperature span. Silastic was first molded (*Cont. Pg. 2*)

SILICONES LUBRICATE RUBBER AND PLASTIC COMPONENTS IN KELVINATOR REFRIGERATOR

The problems generally associated with lubricating moving rubber or plastic parts in contact with metal are easily solved today with silicone fluids and greases. Good examples are found in these applications for Dow Corning 200 Fluid as a lubricant for plastics in the new Kelvinator "Foodarama."

Combining permanent resistance to oxidation and moisture with a flat temperature-viscosity curve, 200 Fluid provides excellent, long term lubrication for—

(A) acrylonitrile-styrene copolymer hinge pins on the "Breakfast Bar" doors;

(B) nylon roller bearings mounted on steel pin shafts that support the roll-out shelves;

(C) polystyrene tracks that provide a sliding surface for the porcelain-enameled crispers;

(D) contact point between vinyl door gasket and polystyrene trim on the cabinet;

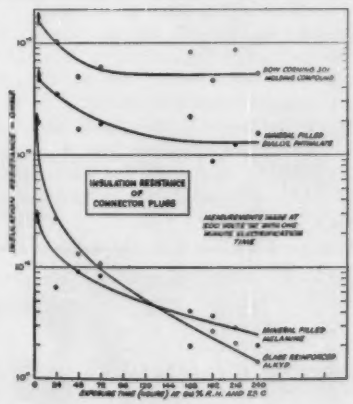
(E) nylon roller bearings that support the steel roll-out basket and the nylon spacers that slide on the steel side rails of the basket.

Applied as a 20-1 dilution in toluene or wiped on full strength, the 200 Silicone Fluid used on the Foodarama is extremely economical. The coating on (*Cont. Pg. 2*)

Silicone Molding Compound Has Better Insulation Resistance Than Plastics

While Dow Corning 301 Molding Compound is frequently specified for electrical parts because of its outstanding resistance to high temperatures, this versatile material also has electrical properties superior to comparable plastics at room temperature. Take insulation resistance, for example—

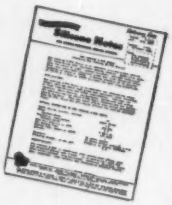
The accompanying graph traces a summary of tests run on four miniature 26-contact connectors molded by Continental Connector Corporation, Long Island City, N. Y. All plugs were identical in physical



*T.M. REG. U.S. PAT. OFF. (*Cont. Pg. 2*)

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Dow Corning Silicone Compounds, for dielectric applications, for release of plastic and rubber moldings, and for protecting finely machined thread parts, are described and compared in a handy reference pamphlet. *No. 344*

Dow Corning 2106 Resin. A recently revised data sheet on this high-strength, silicone laminating resin contains added information and comprehensive tables and graphs on physical and electrical properties. *No. 345*

Looking for a near-at-hand source of supply for parts or products made with Dow Corning Silicones? We'll be glad to send you any of the following:

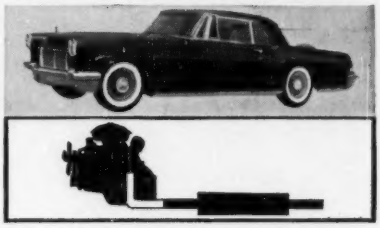
Paint Formulators or Manufacturers ... *No. 346*
Masonry Water Repellent Formulators .. *No. 347*
Laminators of silicone-glass parts ..... *No. 348*
Manufacturers of Class H Motors ..... *No. 349*
Manufacturers of Class H Transformers . *No. 350*
Manufacturers of Class H Insulating Materials ..... *No. 351*
Distributors of Class H components; silicone greases and compounds ..... *No. 352*
Fabricators of silicone rubber parts, wire and cable ..... *No. 353*
Producers of pressure sensitive tape .... *No. 354*

All New — 1957 Guide to Dow Corning Silicones is a twelve page, fact-filled catalog which briefly describes the silicone products of interest to most industries. Containing latest data and information, the guide is designed expressly to help you enjoy the advantages, profits, and savings made possible through imaginative use of these unique engineering materials. *No. 355*

Antifoam B, a new silicone defoamer, has greater stability than any other water dilutable silicone foam-killer commercially available. Will not separate, oil out, plate out, settle or precipitate in most applications. Retains uniformity and effectiveness even if frozen or boiled. Ready to use, it eliminates need for diluting or pre-mixing. *No. 356*

MANIFOLD ON LINCOLN "CONTINENTAL" PROTECTED WITH SILICONE BASED PAINT

Growing numbers of designers are solving the problems of keeping a finish on hot metal surfaces by specifying finishes formulated with Dow Corning Silicones. There could hardly be a more impressive example of the serviceability realized with silicone based paint than the exhaust manifold application on Ford's Continental Mark II.



Ford's selection of a silicone based finish goes back to the 1952 Lincoln, the *first* automobile to feature exhaust manifolds and crossover connections finished with a silicone based service-type paint. This original automotive use of a silicone based finish was highly successful; the coating was as black and glossy as when new after 100,000 miles at temperatures up to 500 F and exposure to road salt, slush, and water.

The current Continental application, however, is even more severe. Applied to a flexible metal bellows that connects manifold and exhaust, a "Sicon" finish made with Dow Corning silicone resins by Midland Industrial Finishes, Waukegan, Ill., is exposed to constant flexing and temperatures in the 500 F range. Nevertheless, the heat stable finish resists chipping and flaking. In addition to providing the most practical protection for metals that get hot in service, silicone based finishes offer excellent resistance to moisture, oxidation, chalking, fading and chemical attack. *No. 342*

SILICONES LUBRICATE REFRIGERATOR *(Cont.)*

the crisper covers, for example, costs a mere $0.0063 per cover!

Performance and economy like this typify Dow Corning silicone fluids and greases. They not only retain efficient lubricity at temperatures far above and below the limits of the best organic lubricants obtainable, but they actually tend to lengthen the life of rubber and plastic components. For many applications involving heat, cold, rubber and plastics, silicone lubricants offer the closest thing to "permanent lubrication" yet developed. *No. 340*

SILASTIC ELIMINATES SLIPPAGE *(Continued)*

and cured on feed rolls for this purpose in 1950 by Immel Engineering & Development Company, Dallas. Silastic coated rolls have been standard equipment on all Atlantic oscillographs ever since; no replacements have been necessary to date; errors due to paper slippage have been practically eliminated and are now completely disregarded. *No. 341*

SILICONE COMPOUND vs PLASTICS *(Continued)*

form, but each was molded from a different material as indicated on the graph.

Not only did the plugs made of 301 Molding Compound have the highest initial insulation resistance, but their margin of superiority broadened substantially after 240 hours at 96% RH. These tests were conducted at room temperature; at elevated temperatures the superiority of the silicone molding compound is even more pronounced.

Performance like this is one of the reasons why Continental, among the world's largest producers of connectors, reports increasing interest in "301" molded units. Already undergoing tests in guided missiles, industrial ovens and even kitchen ranges, 301 Molding Compound is manufactured to meet Specification MIL-M-14E, Grade MSI-30. Continental has announced that its entire connector line will soon be available in 301 Molding Compound. *No. 343*

Dow Corning Corporation, Dept. 6813, Midland, Michigan

Please send me: 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356

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SILICONE NEWS is published for product design and development engineers by

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MIDLAND MICHIGAN

first in silicones
DOW CORNING SILICONES

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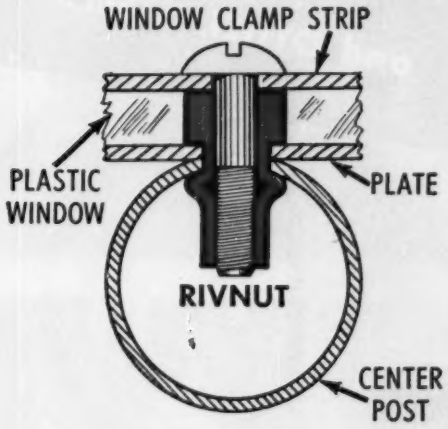
B.F.Goodrich Rivnut

provides blind nutplate so solid it's a shockproof seal

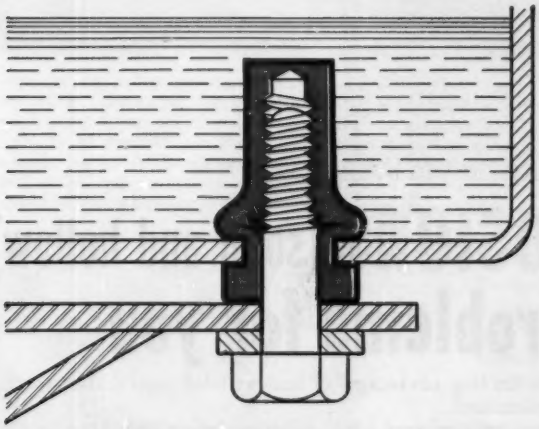


Here's a tough fastening problem that puzzled designers of airplane windows. They needed a nutplate and a blind rivet solid enough to serve as a shockproof seal. One B. F. Goodrich Rivnut solved the problem by performing all three jobs in one operation.

In seconds, one man upsets the Rivnut, securely rivets the plate to center post. The firm bulge in the Rivnut shank conforms to the curvature of the tube, giving a shockproof seal that keeps weather out. Rivnut head serves as spacer for plastic window, and provides 6 clean, firm threads that hold clamp strip and window securely in place.

Best of all, Rivnuts cut costs by reducing assembly time. Here's a typical example:

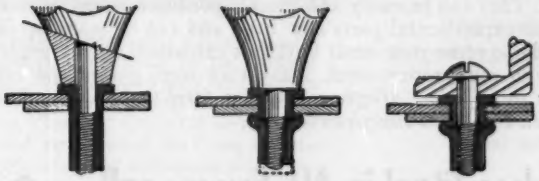
RIVNUT cuts fastening time 90% by eliminating brazing and tapping



A manufacturer of industrial oilers was brazing nutplates on his reservoir tanks for bolting to brackets. This required three separate operations—brazing, tapping, and thread cleaning. Too often, brazing caused warping and leaks. In addition, he had to fuss with bolts and washers to maintain proper shim space.

By switching to Rivnuts, he reduced all three steps to one quick operation. Rivnuts cut assembly time 90%, assured uniform quality in every product. Rivnuts can work wonders for you, too. Call on us for engineering help, or:

HOW RIVNUTS PROVIDE AT LEAST 6 CLEAN THREADS IN ONE SIMPLE OPERATION:



1 Rivnut is threaded onto pull-up stud of heading tool, then inserted.

2 Tool lever operates pull-up stud forming a bulge in the Rivnut shank.

3 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

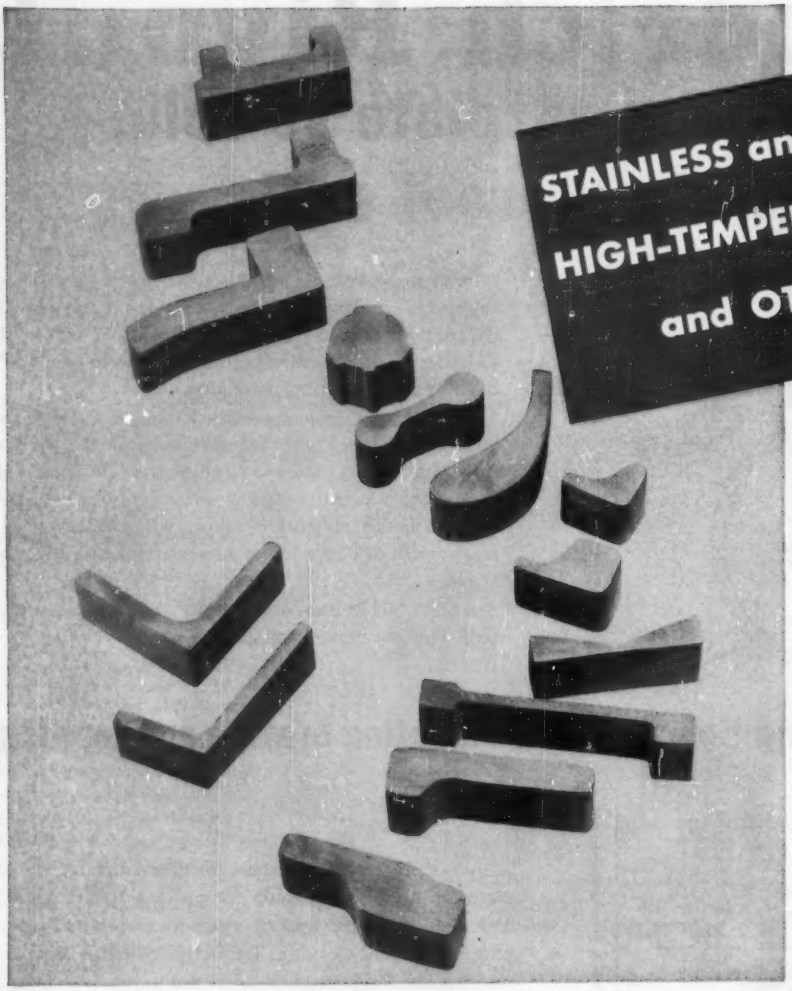
Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to *B. F. Goodrich Rivnuts, Dept. MD-17, Akron, Ohio.*

B.F.Goodrich

AVIATION PRODUCTS

a division of The B. F. Goodrich Company, Akron, Ohio

Circle 445 on page 19



A-L HOT EXTRUSIONS (solid and hollow) may solve problems for you

Help! (Dept. MD-85)

We have a parts problem that hot extrusions might solve. Let's see an AL representative for facts and figures.

- ☐ STAINLESS STEEL
- ☐ TOOL STEEL
- ☐ HIGH TEMPERATURE STEEL

Name_____

Company_____

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Where can these leading advantages of hot-extruded special alloy steels apply to your production?

1. Hot extrusions require very little finishing before use, even in the case of involved shapes. The scrap loss is small and you can buy raw materials closer to finish size. You buy less high-cost steel, cut away less of it . . . save both in time and material cost.

2. The range of shapes, solid or hollow, which can be hot-extruded is almost infinite. They can be easily and quickly produced in any quantity. Dies for new or experimental parts cost little and can be made up fast.

● We're ready to serve your needs with hot extrusions in any grade of stainless or high temperature steel, many tool steel grades and other steels. Call us in to help. ***Allegheny Ludlum Steel Corporation, Oliver Building., Pittsburgh 22, Pennsylvania.***

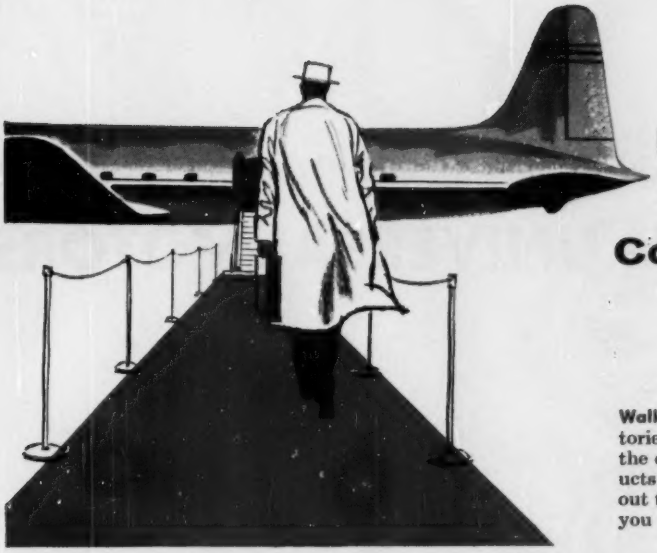
For Stainless Steel in ALL Forms—call

Allegheny Ludlum

AL STAINLESS STEEL

WSW 5310A

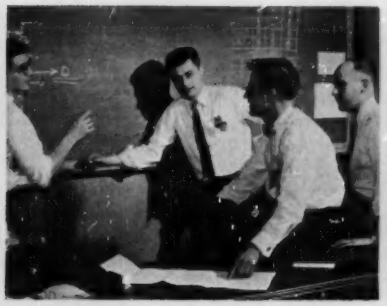
Circle 446 on page 19



OPPORTUNITY keynotes your career in the IBM Airborne Computer Laboratories

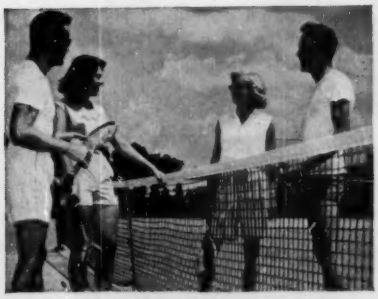
Walk the red carpet to IBM's Airborne Computer Laboratories in Owego, New York, to see for yourself, first-hand, the challenging *opportunities* available in Military Products engineering. Talk with the men who are now carrying out these advanced projects and let their enthusiasm stir you to join our ranks.

Opportunity in Engineering: High-speed electronic computers, both digital and analog types, are developed within the ACL to fit specific Air Force requirements. As an ACL engineer, you will find ample *opportunity* to put your talents to work in a variety of assignments.



Opportunity to learn: If you believe *knowledge is your greatest security*, ACL offers *opportunities* to obtain advanced degrees, attend seminars, training courses; to consult with renowned experts and to prepare yourself for greater responsibility.

Opportunity for adventure: IBM Flight Test engineers fly with the Air Force in B-47 and B-52 aircraft, checking the dynamic operation of our airborne equipment. Field Engineers work on the flight line, maintaining operating production systems.



Opportunity for better living: Ideally located Owego, close to the Finger Lakes, offers you and your family every *opportunity* for recreation and pleasant living. The IBM C.C. (725 acres) offers diverse recreational facilities for the family, including swimming pools, two golf courses, rifle range, bowling, etc.

Exceptional career opportunities are now open at the IBM Airborne Computer Laboratories for E.E.'s, M.E.'s, physicists, and mathematicians, in the following fields:

Digital and Analog Systems	Reliability	Power Supplies
Inertial Guidance	Components	Transistors
Servo-Mechanisms	Physics	Heat Transfer
Electronics	Mathematics	Optics
Mechanical Design	Human Factors	Test Equipment
Packaging	Installation	Cost Estimating

Tremendous job flexibility enables ACL to custom-fit the engineer to the job. ACL offers you small-company advantages with large-corporation security. IBM's salaries are excellent; company benefits tops for industry. The rate of turnover at IBM is less than 1/6 the national average.

For more information, write, outlining background and experience, to: R. A. Whitehorne, Room 7901, International Business Machines Corporation, 590 Madison Avenue, New York 22, New York.

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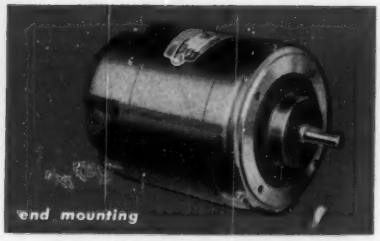
IBM MILITARY PRODUCTS

Circle 447 on page 19

from industrial sewing to modern accounting...

RUGGED R & M UNIVERSAL MOTORS



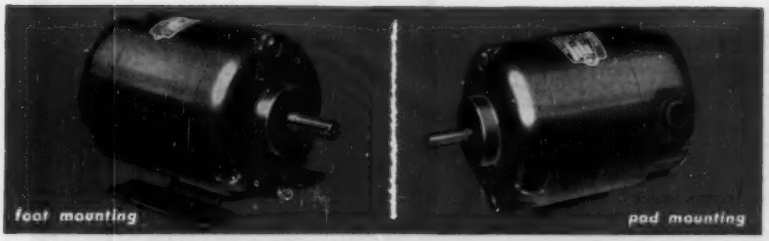
available in sizes
from 1/50 to 1/2 horsepower

PROVIDE DEPENDABLE PERFORMANCE!

VERSATILE R & M Universal Motors are engineered to provide the best power component possible for your product, capable of years of trouble-free performance. Note these outstanding features of R & M Universal motors: pad base, foot base or end mountings permit versatility in the design of your product; cast iron heads have clean appearance, excellent accuracy; double shielded ball bearings keep grease in, dirt out; armatures are dynamically balanced for quiet, vibrationless operation; sturdy commutators and brush holders are selected with infinite care.

Standard R & M Universal motors are available in ratings from 1/50 to 1/2 h.p. Other ratings are available through custom design to your specific applications!

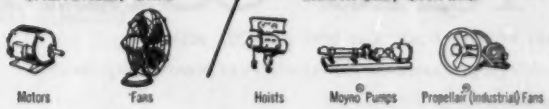
Write for Bulletin 444-MD and name of your R & M representative.



R&M®

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO



Motors Fans Hoists Moyno® Pumps Propellair® (Industrial) Fans

Circle 448 on page 19

MOTIONS-IN-MINIATURE
CLUTCHES BY FORMSPRAG

ACTUAL SIZE

Now! The modern sprag principle comes to small over-running clutches

Formsprag—pioneer in the development of sprag-type clutches—now offers a truly versatile small clutch for hundreds of varied applications.

In terms of your product's performance, Formsprag FS-02 and FS-04 clutches provide unusual compactness, utmost accuracy and torque, simple and dependable operation. And they are easily adapted to a large variety of mounting arrangements.

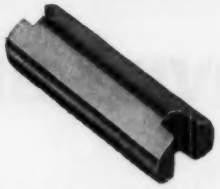
Manufacturers of automatic coil-winders, stamping machines, laundry machines, table band saws, etc. are already utilizing these versatile clutches. Why not profit by their experience?

HERE'S REAL COMPACTNESS

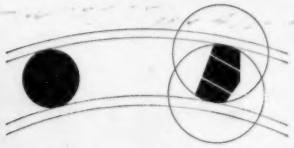
	Bore Size	O.D.	Torque	Over-running Speed
Model FS-02	¼"	1¼"	50 in. lbs.	*2400
Model FS-04	⅜" and ½"	1⅝"	200 in. lbs.	*2400

*Higher speeds possible on special applications. Consult with factory.

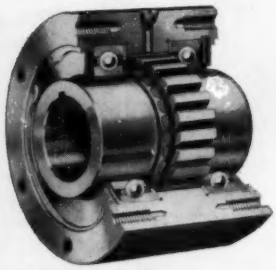
WHY IT PAYS TO DESIGN "THE FORMSPRAG PRINCIPLE" INTO YOUR PRODUCT



Sprags are an advanced design of precision wedges made of hardened alloy steel. Utilized in a clutch, they increase the efficiency and prolong the life of all equipment using an over-running clutch or ratchet.



The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space—therefore, of increased torque capacity.



Basic construction of the Formsprag Clutch is simple. A full complement of sprags is inserted between inner and outer concentric races. Contact with both race surfaces is maintained by energizing springs.

MORE INFORMATION?

Should you require details on these Formsprag small clutches as well as the complete line, write today for this new 26-page catalog.

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications

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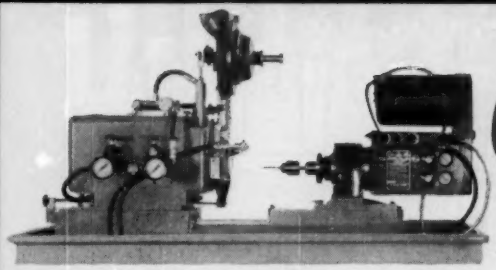
World's largest exclusive manufacturer of over-running clutches

Distributors in principal cities

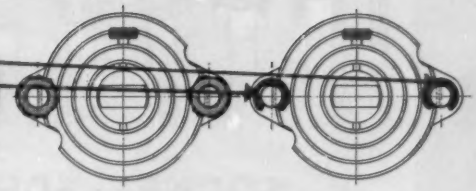
A5-10

Waldes Truarc Retaining Rings Eliminate Machining and Parts—Cut Assembly Time on Drill and Tapper



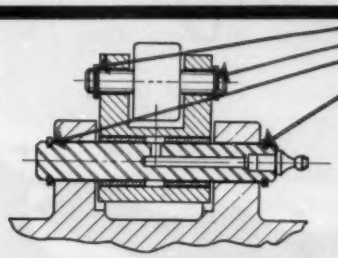
Beco Model 410 Drill and Tapper

The Batchelder Engineering Co., Inc., Springfield, Vermont uses 4 different sizes of 2 different type Waldes Truarc rings in their new BECO Model 410 Automatic Drill and Tapper. Truarc rings speed assembly, reduce machining, improve design.



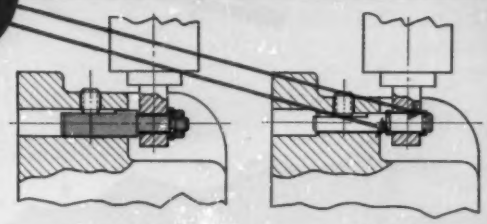
Clamp Cylinder Rod Stop Assembly

Truarc "E" Rings (Series 5133) replace stop nuts in the Clamp Cylinder assembly. They eliminate need for threading 2 rods ...the danger of cross-threading nuts...and costly rejects. Truarc Rings cut assembly time and cost.



Bell Crank Pivot Assembly

Truarc Rings (Series 5100) in Bell Crank Pivot assembly permit grease hole not possible with cotter pin fastener. Use of nuts would have increased machining and assembly costs considerably.



Hopper Cylinder Anchor Pin Assembly

2 Truarc Rings (Series 5100) secure and position end of vertical air cylinder. Rings eliminate extra cost of machining 3-diameter pin, threading and undercutting...plus nut and washer. Assembly is quick and sure.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

WALDES

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WALDES KOHINOOR, INC.
47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

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Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name .....
Title .....
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Business Address .....
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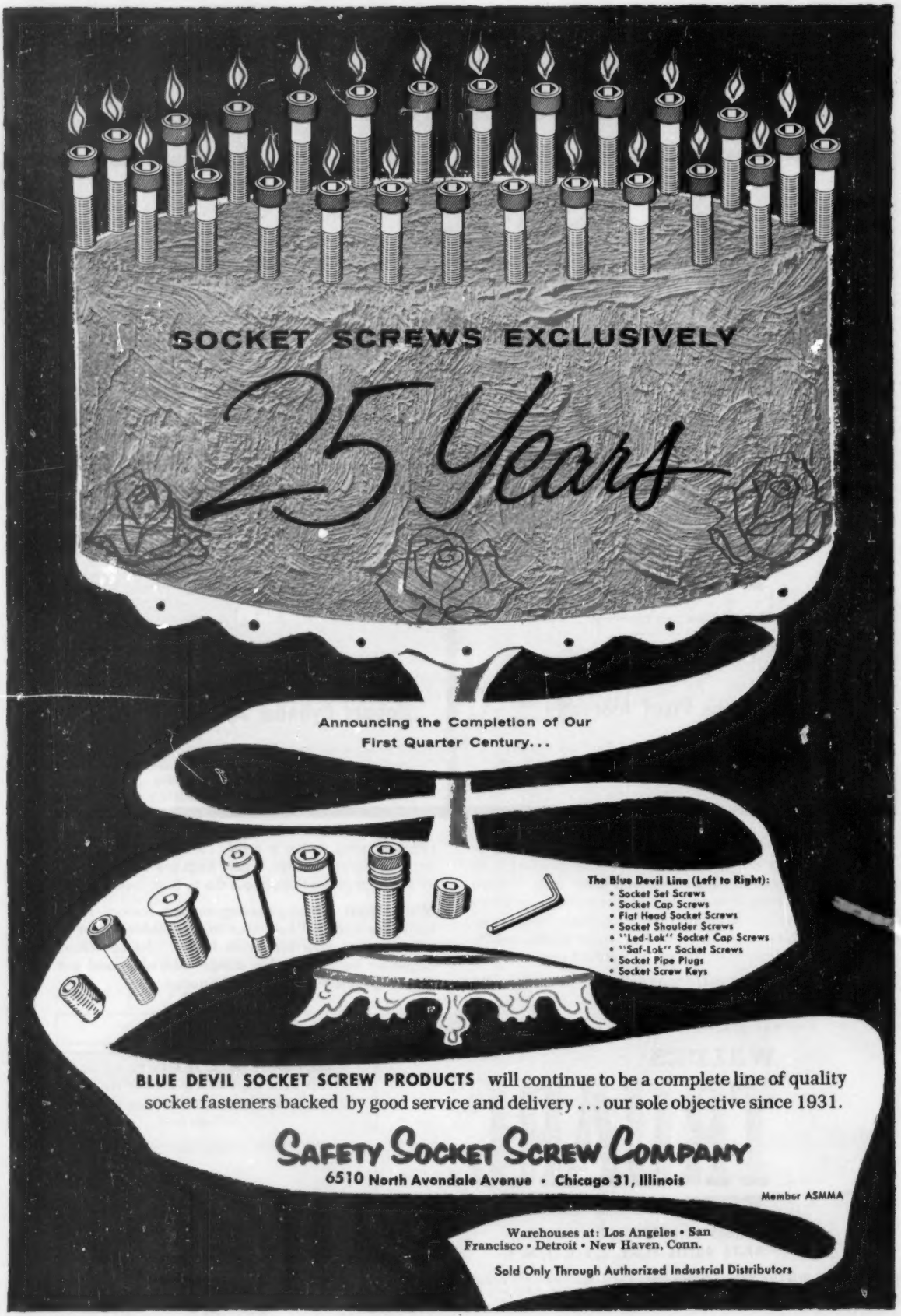
WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.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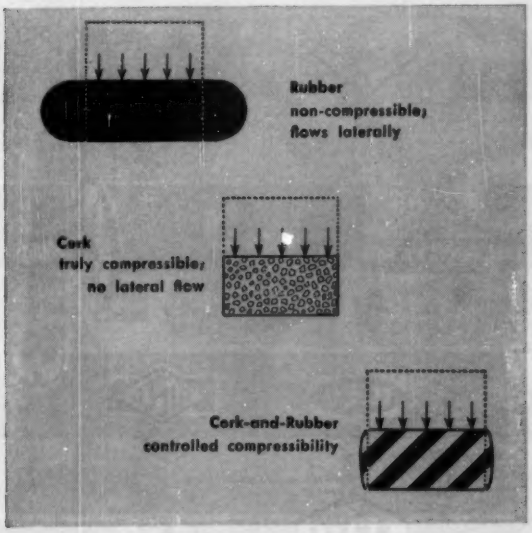
How to cut the cost of O-rings

Lathe-cut, compressible cork-and-rubber rings often can reduce your O-ring costs substantially. At the same time, they may effect savings in machining time and inventory costs. Here's why:

Molded rubber O-rings are incompressible and therefore must be made to very close tolerances to allow perfect fit between the flanges. An O-ring too small in cross-section will not seal effectively . . . and an oversize O-ring will prevent flange contact.

Cork-and-rubber compositions, on the other hand, combine the compressibility of cork with the non-compressibility of straight rubber compounds. This compressibility can be controlled and compositions produced which are nearly as compressible as cork, or almost as incompressible as rubber. The percent of compression for cork-and-rubber rings may range, therefore, from 20% to 33%.

In some applications, the wider tolerances permissible with compressible lathe-cut rings may effect savings in machining time. In other cases, it may be possible to reduce inventories because one size of



cork-and-rubber ring may work where two or more rubber O-ring sizes might otherwise be required.

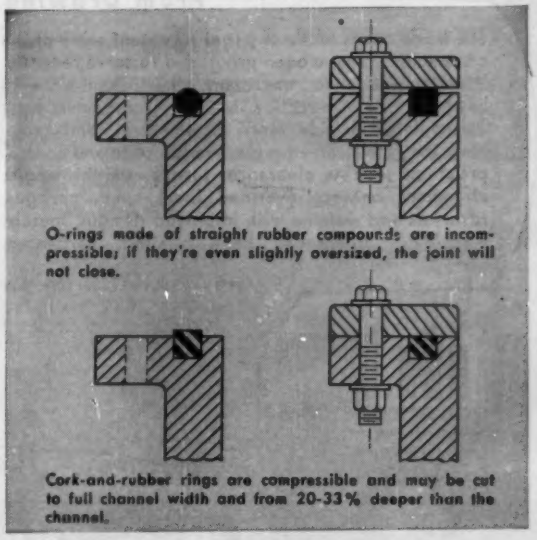
Armstrong Cork-and-Rubber Rings can be cut to fit existing channel dimensions (from ⅜" to 20" I.D.), with no change required in channel size or design.

Imperviousness

All lathe-cut Armstrong cork-and-rubber compositions are impervious. Their rubber binder encloses each cork particle in a continuous matrix. Cork-and-rubber can be used to seal high internal pressures. The upper and lower temperature limits vary with the different compositions and with the fluids to which they are exposed. In most cases, continuous operating temperatures should not exceed 300° F.

Solvent resistance

The solvent resistance of cork-and-rubber compositions is comparable to straight synthetic rubbers of corresponding base polymers. For example, cork-and-chloroprene-type synthetic rubber is normally used with lubricating oils, and for general purpose applications where some swell is desired or can be


O-rings made of straight rubber compounds are incompressible; if they're even slightly oversized, the joint will not close.

Cork-and-rubber rings are compressible and may be cut to full channel width and from 20-33% deeper than the channel.

tolerated. Cork-and-nitrile-type synthetic rubber provides good gasoline and aromatic-solvent resistance and has less tendency to swell or stick on metal surfaces. Cork-and-styrene-type synthetic rubber compounds, however, have very limited solvent resistance and should not be used for these purposes.

SEND FOR 24-PAGE GASKET MANUAL

You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy to Armstrong Cork Company, Industrial Div., 7101 Dean St., Lancaster, Pa. For information on all Armstrong Gasket Materials, see Sweet's product design file.

Armstrong
GASKET MATERIALS
. . . used wherever performance counts

Circle 452 on page 19

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Powerful as the Nation
AMERICA'S STANDARD
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THE BLUE BOOK OF AMERICAN INDUSTRY
From Drawing Board to Production
JOY
The trade marks on these pages represent some of the companies we have been privileged to serve recently. Working with them, and many others, from drawing board to final production, Mechanics engineers have accumulated a wide range of universal joint know-how. They have solved power transmission and control problems such as clearance, torque, weight, angle, alignment, balance, overload, shock, speed changes, reversals and stamina with improved designs, metals, machining, tolerances, heat treating, hardening, balancing and lubrication. By designing and building drive lines that are specifically suited to the operating characteristics of each machine, Mechanics universal joint engineers have helped the engines in the products represented on these pages to deliver maximum power to the wheels. The drafting board stage is the time to design more efficient power transmission into your product. We invite you to benefit from Mechanics engineers' universal joint experience when planning your next model.
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welded stainless pipe that's smoother, stronger

New Contour-Trentweld outperforms any other pipe, welded or not. Here's why: *Contour-Welding* is an entirely unique method of producing pipe and tubing. It puts gravity to work to pull down the molten weld metal until it exactly conforms to the contour of the pipe. Result: A smooth pipe or tube free of undercut or bead.

What's more, the *Contour-Weld* process *starts* with uniformly rolled stainless strip, which insures constant wall thickness throughout the pipe.

But the only way you can fully appreciate the advantages of new *Contour-Trentweld* is to try it. We think you'll agree, *it can't be beat by any other pipe, welded or not.*

Why Trent's Exclusive Contour-Welding Process Means Smoother Welds...

Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most – right on the I.D. surface. If you try to get rid of the bulge – at fair cost – the metal is undercut – and corrosion and erosion start there.

But Trent put a stop to that – simply by going into partnership with gravity. With their exclusive *Contour-Welding* process, they weld at the bottom – and gravity works for them. For then, the bulge is in the opposite direction – blending in perfectly with the contour of the pipe itself.

CONTOUR TRENTWELD

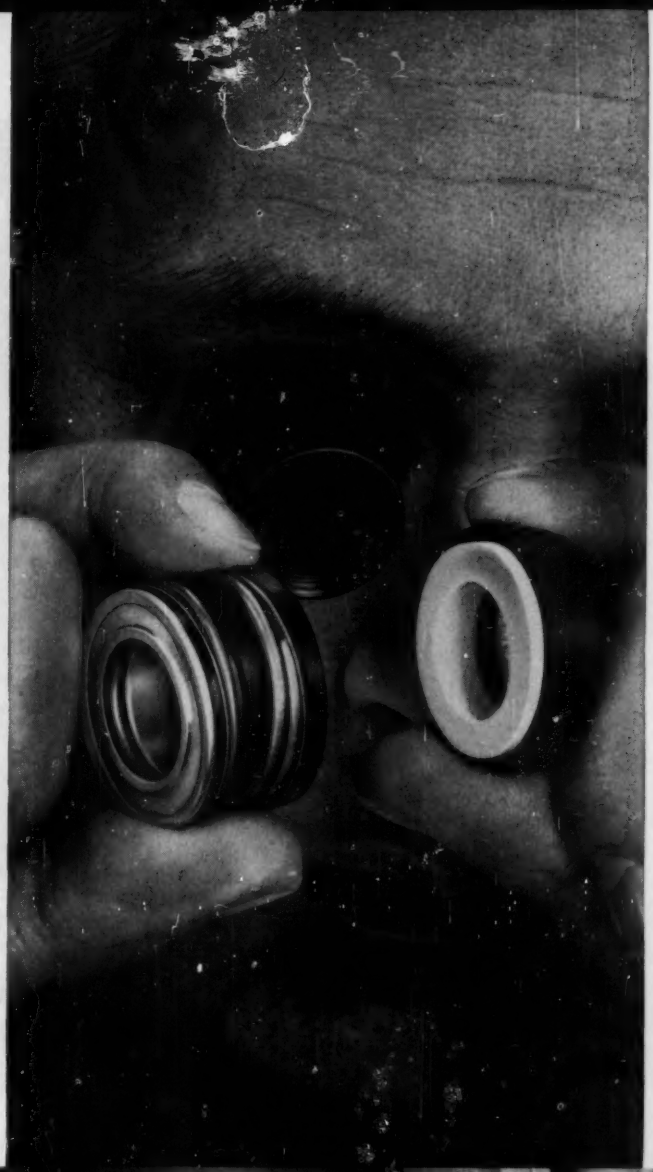
Stainless and High Alloy Welded Tubing

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)

NEWEST OF THE GARLOCK **2,000**

New LOW COST GARLOCK MECHANICAL SEAL

has "Gem-like" Qualities!



The finest quality materials, design, and workmanship have been incorporated in this new low cost Garlock Mechanical Seal for ⅝" to ¾" diameter shafts.

This new low cost mechanical seal is another important addition to "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. The only complete line . . . that's why you get unbiased recommendations from your Garlock representative.

True Carbon Seal Ring with precision lapped surface. Regarded by all experts as the finest material for one face of any mechanical seal. Perfectly flat sealing surface contacts stationary seat.

Stationary Seat of finest Ceramic is mounted in a molded cup-shaped vibration ring. Its sealing surface is precisely lapped for perfect contact with the carbon seal ring . . . perfectly matched for positive sealing.

Costly Two-piece Shell Construction. Shell rolls over a retainer ring which holds "O" Ring (static seal) in place and also provides a metal surface which gives you an exact mounting position. No danger of incorrect mounting due to improperly located static seal.

Static "O" Ring in Groove permits mounting seal from either direction without disturbing position in shell. Withstands higher pressures (100 psi.) and permits tighter fits than square shaped rings.

Roll Type Bellows provides greater travel than "V" type bellows.

We invite you to compare this new inexpensive Garlock seal with those you are now using. It is designed for use on any rotating shaft of home water pumps, oil pumps, reduction units, washing machines, etc. Get all the facts, call your local Garlock Representative or write for data sheets on this new mechanical seal.

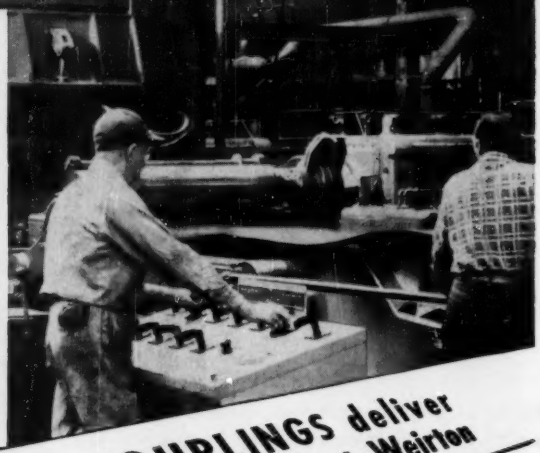
THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

Circle 455 on page 19



TEN AJAX DIHEDRAL COUPLINGS deliver 25,000 H.P. on new U E & F mill at Weirton

Close-up shows two of five pairs of Ajax Dihedral Spindle Couplings driving 23" and 56" x 52" 4 high 5 stand tandem cold mill built by United Engineering & Foundry Co. for Weirton Steel Co., a Division of National Steel Corporation.

▶ The critical eyes of steel men are focused on the design, performance and output of every new mill and all its components. This new 4 high, 5 stand tandem cold mill, designed for speeds up to 7200 fpm, was built by United Engineering and Foundry Co. for the Weirton Steel Co., a Division of National Steel Corporation.

It is turning out sheet of high quality finish and maintaining close gauge tolerance.

Power is transmitted from drive stands to rolls by 10 Ajax Dihedral Spindle Couplings handling 2500 H. P. each. The uniform angular velocity of Ajax Dihedral Spindle Couplings is an important factor in producing smooth finish, uniform thickness and long roll life.

Ajax Dihedral Spindle Couplings are in operation in America's foremost steel mills. They have been proved and approved by every test of time and service. Whether you are designing, specifying, building, using or modernizing mills, it will pay you to get the facts on Ajax Dihedral Spindle Couplings.

Write for Bulletin No. 58.

AJAX®

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, N. Y.

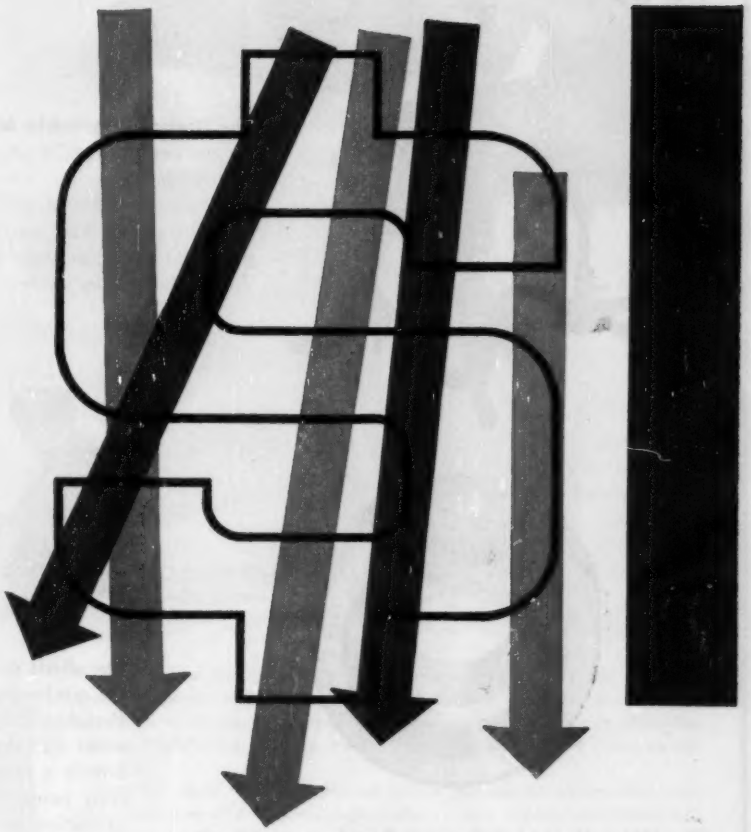
Circle 456 on page 19

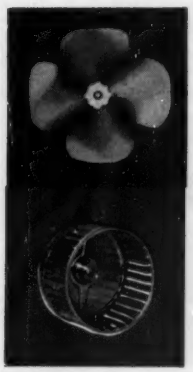
CLOSE TO THE 4 BILLION DOLLAR MARK

Torrington air-impellers are contributing to the quality and saleability of products valued at nearly $4 billion a year. A partial list of product categories:

Room air conditioners
Automobile heaters and air-conditioners
Cooling towers
Commercial coolers
Window ventilators
Kitchen fans
Hassock fans
Electronic cooling devices
Space heaters
Oil burners
Unit heaters

If you have a design or manufacturing problem involving air-impeller equipment, Torrington's industry-wide reputation is your assurance of quality and service.





THE
TORRINGTON
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT
VAN NUYS, CALIFORNIA · OAKVILLE, ONTARIO

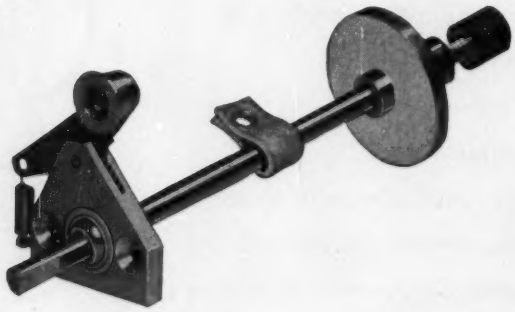
Circle 457 on page 19

Offset or aligned . . .

HEIM *Unibal* BEARINGS

operate smoothly

The **Diebold Portable Microfilm Camera** weighs only 20 lbs., is about the size of a portable typewriter, yet it is one of the fastest and lowest cost methods of making a copy—a microfilm copy in a split second, that projects to full size onto a brilliantly illuminated reader screen.



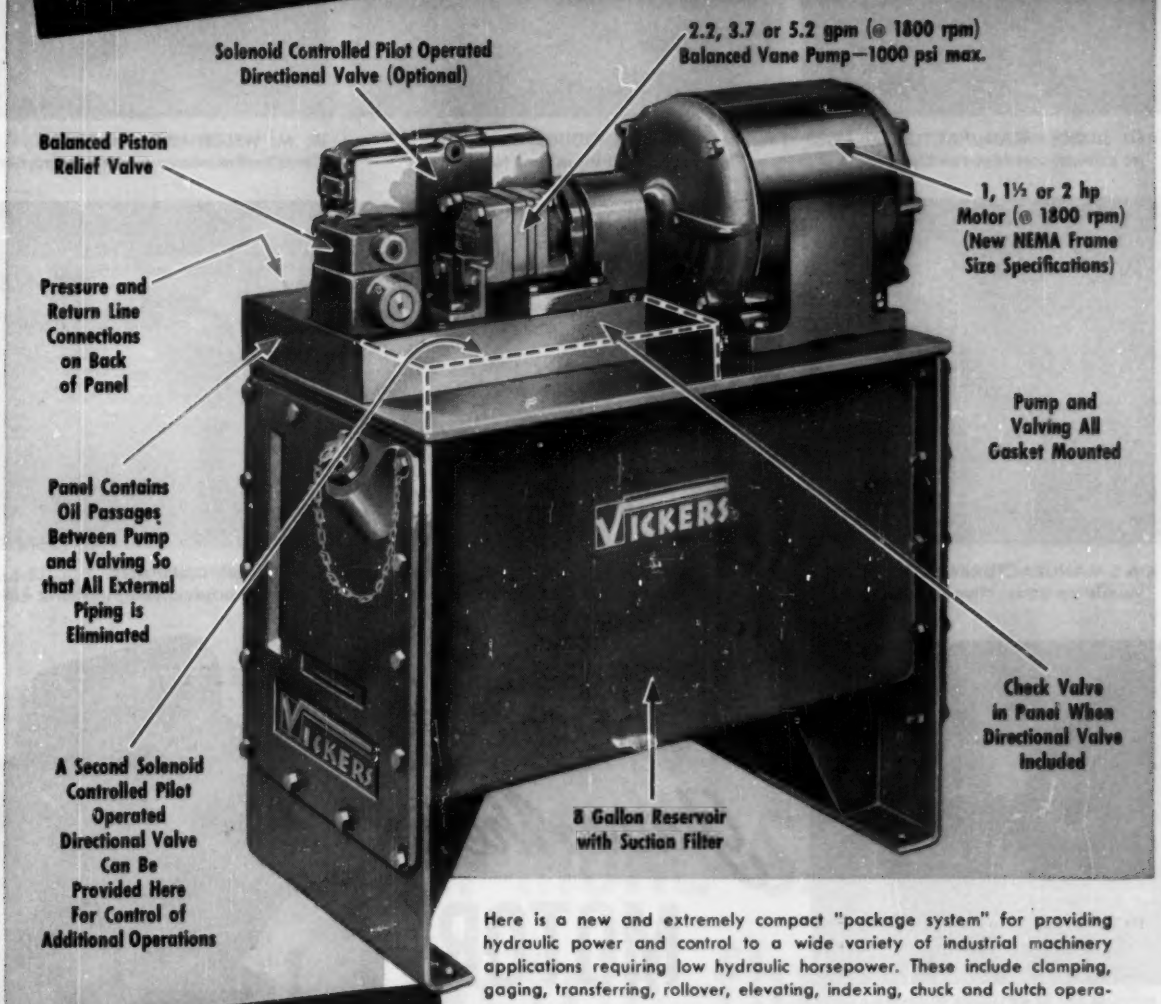
The **Heim Unibal Spherical Bearing** consists of a single ball (through which the shaft passes) revolving in bronze bearing inserts which are housed in the bearing body. This Unibal type of bearing has a large surface supporting area; carries heavier loads where required; and corrects shaft misalignment in all directions.

A wide range of stock sizes is carried by Heim distributors across the U.S.A. and in Canada. Heim Unibal Bearings, Heim Unibal Rod Ends, and the complete line of Pillow Blocks, Flanged Bearings, etc. are listed in Heim catalog No. 100. Be sure you have the latest copy in your engineering department.

The **shaft and bearing assembly** shown is the mechanical heart of the Diebold 9600 Portable Microfilm Camera. The rubber roller on the end of the shaft drives film in a film magazine in synchronism with copy being photographed. Smooth operation of this shaft is imperative since any hesitation or binds will show up on the film as density bars in the picture. The shaft rotates in a horizontal position continuously, and, when copy is being fed into the camera, a cam raises the shaft 5 to 10 degrees out of alignment to contact the film. A loose bearing could be used to permit this misalignment, but might result in irregularities. With the Heim Unibal Bearings, the smooth operation necessary is assured in either the offset or the aligned position of the shaft.

THE HEIM COMPANY / Fairfield, Connecticut

A NEW IDEA . . . in hydraulic power and control systems


Solenoid Controlled Pilot Operated Directional Valve (Optional)
2.2, 3.7 or 5.2 gpm (@ 1800 rpm) Balanced Vane Pump—1000 psi max.
Balanced Piston Relief Valve
1, 1½ or 2 hp Motor (@ 1800 rpm) (New NEMA Frame Size Specifications)
Pressure and Return Line Connections on Back of Panel
Pump and Valving All Gasket Mounted
Panel Contains Oil Passages Between Pump and Valving So that All External Piping is Eliminated
VICKERS
Check Valve in Panel When Directional Valve Included
A Second Solenoid Controlled Pilot Operated Directional Valve Can Be Provided Here For Control of Additional Operations
8 Gallon Reservoir with Suction Filter

Here is a new and extremely compact "package system" for providing hydraulic power and control to a wide variety of industrial machinery applications requiring low hydraulic horsepower. These include clamping, gaging, transferring, rollover, elevating, indexing, chuck and clutch operations, etc.

Note the many features indicated on the photograph above. The result is improved and simplified hydraulic design . . . also reduced installation and maintenance costs. This "package system" has great flexibility . . . is available in a wide variety of combinations of standard components assembled to suit individual requirements. Pretested and ready for immediate operation, it has also the advantage of undivided Vickers responsibility. For further information, ask for installation drawings 178706-8.

VICKERS Series T8 HYDRAULIC PIPELESS POWER PACKAGE*

7311

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

ADMINISTRATIVE and ENGINEERING CENTER

Department 1430 • Detroit 32, Michigan

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N. J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • TULSA • WASHINGTON • WORCESTER

IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

*These "package systems" supplement the Vickers line of standard hydraulic power units.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 459 on page 19

RED JACKET MANUFACTURING CO.
"jet pumps cost less to ship"

LENNOX INDUSTRIES INC.
"we just install them and forget them"

W. M. WELCH MFG. COMPANY
"eliminated heavy mounting frames"

K & S MANUFACTURING COMPANY
"stands up under roughest handling"

ANTHONY MACHINE & ENG. SERVICE
"only motor versatile enough for us"

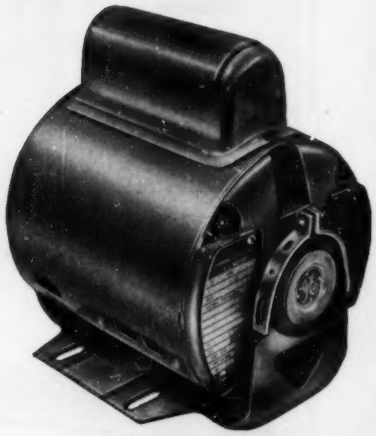
THE TRANE COMPANY
"reduced product weight nearly 8 lbs."

RUTHMAN MACHINERY COMPANY
"more compact, yet full-powered"

GE

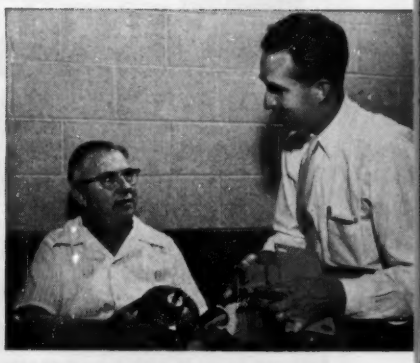
Years Ahead

MOTOR

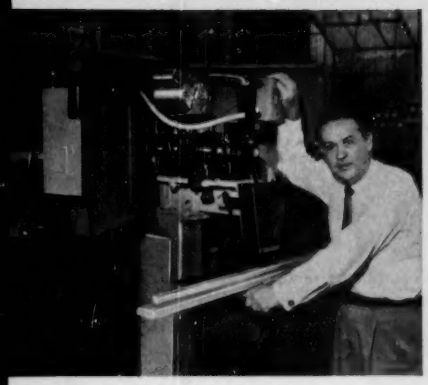


ALBERTSON & CO.—SIOUX TOOLS
"lighter, smaller—with power to spare"

MODINE MANUFACTURING COMPANY
"dependable—in operation *and* delivery"



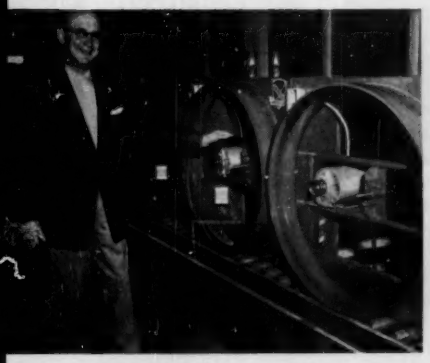
BARBER-COLMAN COMPANY
"cut manufacturing costs 12½%"



AUTO-NAILER COMPANY
"All-angle mounting cuts design costs"

G. C. BREIDERT COMPANY
"as quiet as it is dependable"

LANCASTER PUMP & MFG. CO.
"G-E motors help sell our pumps"



BAR-BROOK MFG. COMPANY
" 'no re-oiling' feature rates high"

SOUTH BEND LATHE COMPANY
"top quality at competitive prices"

TEMCO, INC.
"light weight cut shipping costs"

16 More Companies Say...

LESS COSTS, MORE SALES with General Electric fhp motors

Yes—16 *more* manufacturers, like yourself, have reported on the cost-savings and sales-increases they've realized by incorporating General Electric "Years-ahead" motors into their products.

They are representative of the thousands of companies who have realized similar benefits—adequate proof that this General Electric fhp motor *can* save you money—*can* make your product more saleable.

And no wonder! The G-E "Years-ahead" motor incorporates a number of advanced design features to give you longer motor life, unsurpassed versatility, and a lighter, smaller, more streamlined design to match your own modern product . . . for example—moisture resistant Mylar* polyester film insulation; dependable, all-angle sleeve bearings; doubled lubrication life; removable, rotatable cradle base; and many others.

To find out how you can take greater advantage of these G-E motor benefits in your own product, contact your nearby General Electric Apparatus Sales Office, or write to General Electric Company, Section 702-30, Schenectady, N. Y.

*Registered trade-mark of Du Pont Company.

GENERAL ELECTRIC

Circle 460 on page 19

look at the EXTRA STRENGTH *in these gears*

Notice how the teeth are continuous across the face of each gear in the photo? That is a characteristic of Farrel herringbone gears, which, instead of a useless center groove, have a *backbone* where the helices meet. This puts the entire face width of the gear to work for you. It pays off in *extra strength* and greater load and shock capacity — in smaller space.

The answer lies in the unique method of manufacture. The machines that cut Farrel gears—famous Farrel-Sykes generators—make continuous tooth herringbone gears. The center groove required for tool clearance by other machines is replaced by useful working tooth area.

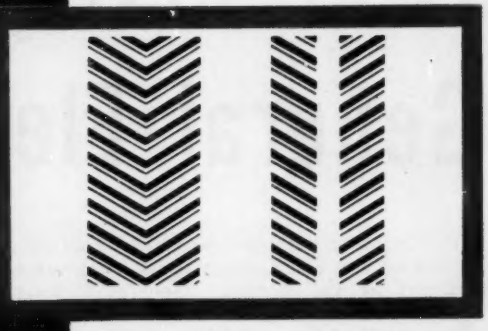
Backbone comes in any size up to 23 feet diameter — for virtually any application. Ask for details.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.

Sales Offices: Ansonia, Buffalo, Boston, Akron, Detroit, Chicago, Minneapolis, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston

FB-1070



This comparison shows the greater tooth area of the Farrel continuous tooth herringbone gear (left) which gives it greater strength than the double helical gear with center groove (right).

Farrel-Birmingham®

Circle 461 on page 19

AVOID the **HIGH COST** and difficulty of fabricating long, hard & straight parts by conventional methods . . .

THOMSON

60 Case

hardened and ground

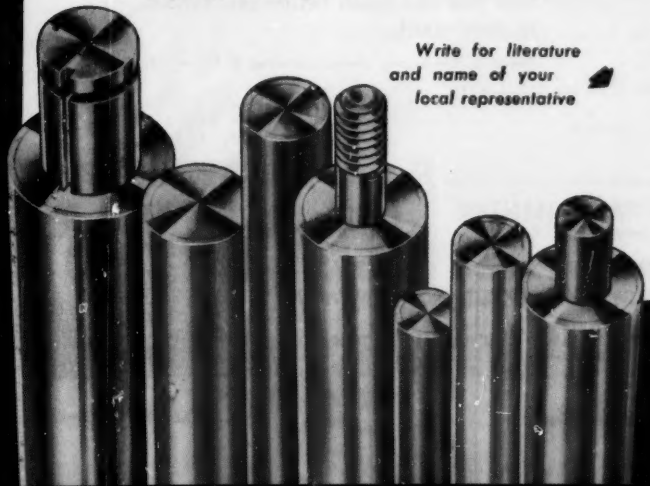
SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining.



Write for literature and name of your local representative

ADVANTAGES of *60 Case*

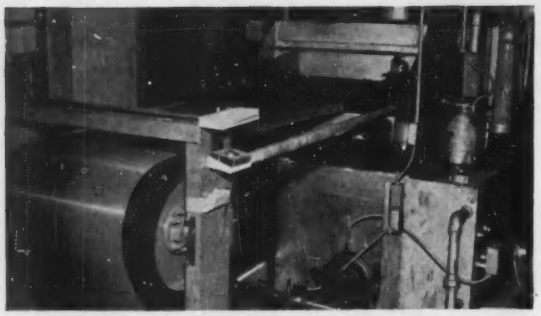
- COST REDUCTION
- HARD BEARING SURFACE
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

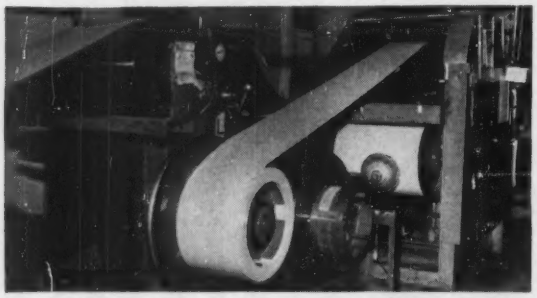
GUIDE RODS, SHAFTING, ROLLS, TRAVERSE RAILS, PISTON RODS, ARBORS, LEADER PINS, TIE RODS, KING PINS, AXLES, CONTROL RODS, GUIDE POSTS, MANDRELS, BEARING ROLLERS, SPINDLES

THOMSON INDUSTRIES, Inc.
Dept. C5, Manhasset, New York

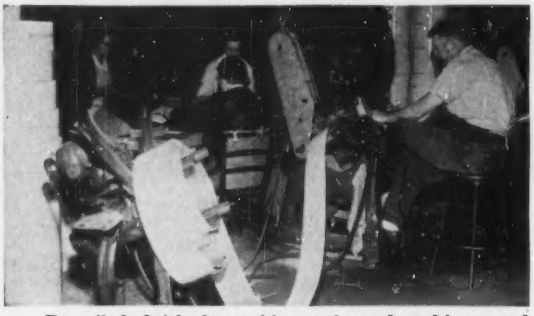
Circle 462 on page 19



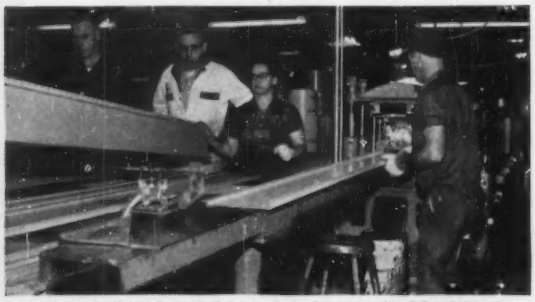
Strip is re-coiled after its treatment with Bonderite, corrosion resistant paint bond.



Painted metal is slit to desired width and coiled again as it emerges from finishing machine.



Re-coiled, finished metal is cut, formed, and inspected here. No loss of paint adhesion.



Painted stock is fed into punch press for blanking into various shapes and sizes.

Photos courtesy Hastings Aluminum Products, Inc.

Bonderized... Painted... Formed...

NO LOSS OF PAINT ADHESION!

Here's a production wrinkle that more and more manufacturers are using: Finish metal in the strip, then fabricate the product.

The technique applies equally well on steel and aluminum. First, run the strip through the Bonderite machine to produce the phosphate integral surface that supplies a secure anchor for the paint. Next, run the Bonderized strip through roll-coat painting and the bake oven. The painted coils of metal are ready for fabrication, and the finish doesn't crack, chip or craze as it is formed, drilled, and punched.

Fabrication after painting, made possible by Bonderizing, saves money by reducing labor, handling and manufacturing area requirements, and allows higher production rates.

Write or call for more information on how you can finish before fabrication in your plant.

Bonderite, Bonderizing, Bonderized—Reg. U.S. Pat. Off.

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1914 — leader in the field

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

PERFORMANCE

O-M Tie-rodless (round line) Air and Hydraulic Cylinders rated to 500 psi Air; to 1500 psi Hydraulic.

O-M CYLINDERS
TIE-RODLESS

• SMOOTH • POWERFUL • DEPENDABLE

air and hydraulic meet JIC standards

O-M Tie-rodless Air and Hydraulic Cylinders deliver peak performance at low or high speeds. They are simple and unique in design . . . have no tie rods or projecting end caps . . . fit easily in unusually close quarters . . . operate with lowest co-efficient of friction . . . and are readily disassembled for servicing. Besides, the ports can be oriented to any position.

Interchangeable mounts make O-M Cylinders adaptable to any installation. All cylinders tested at rated operating pressures before shipment.

Available in full range of sizes (1½" to 8" bores) with standard, 2 to 1 or oversize rods.

mail coupon now!

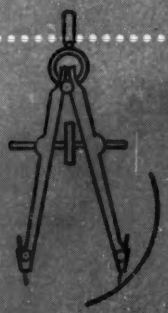
for Bulletin 101A, showing all cylinders, mounts and mounting brackets.

ORTMAN-MILLER MACHINE COMPANY
7 143rd Street, Hammond, Indiana

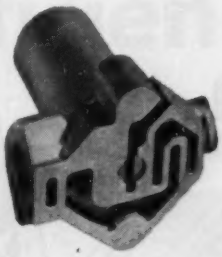
☐ Have Representative call ☐ Send Bulletin 101A (Round Line)

Name_____ Position_____
Company_____
Address_____
City_____ Zone____ State_____

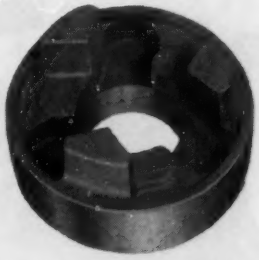
CHARACTERISTICS OF CENTRAL FOUNDRY SHELL CASTINGS THAT WIDEN THE LATITUDE OF **product design**



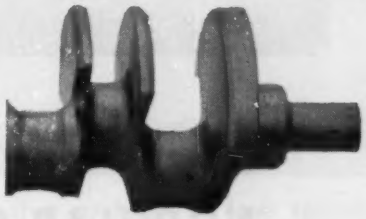
intricate designs which are not practical with sand-castings, can frequently be produced in volume by the CENTRAL FOUNDRY SHELL MOLD PROCESS. Deep pockets can be drawn with a minimum of pattern draft. Pieces can be cast which have grooves and recesses without the need of additional cores, and the relationship of holes to the body portion can be maintained. The governor body is an example of this characteristic of shell castings.



closer tolerances can be held with shell castings than with green sand castings. The transmission drum is a typical example of a piece that gained by being held to very close dimensions. This factor can affect product design by making it possible to take advantage of the strength of alloy grey iron or ArmaSteel in a piece that might otherwise have to be die-cast in a soft metal.



the better dimensional control of shell castings makes it possible to substantially alter the design of a piece. Narrow spaces between counterweights in a crankshaft, for example, can be produced that are impossible in a forging.



smoother surfaces • Shell casting permits excellent duplication of surface detail. The engineer designing a piece that should possess high strength, but also some detail as to surface (such as cast-in lettering) may now find the answer in a shell casting.

shell coring produces more accurate internal surfaces. Because shell cores are cured in the corebox, intricate shapes are possible.

So many characteristics of CENTRAL FOUNDRY shell castings permit improvement in design, in material and in net cost that design engineers in many industries are specifically recommending these castings of grey iron, malleable iron or ArmaSteel. For further engineering data write for new 36-page shell casting manual . . . just completed.

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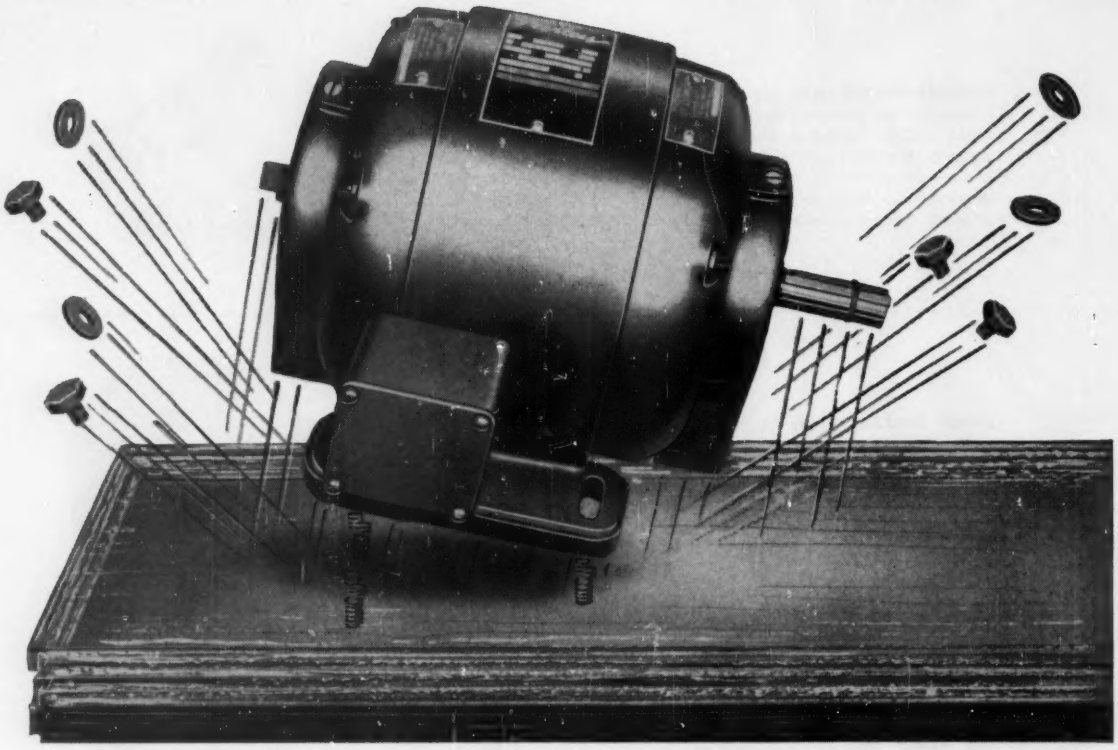
CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14



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Circle 466 on page 19

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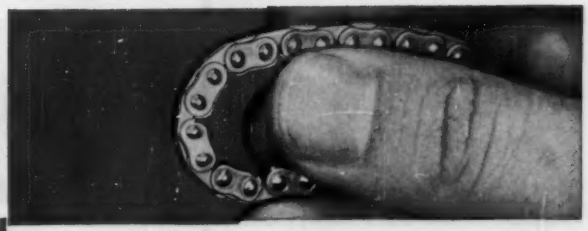

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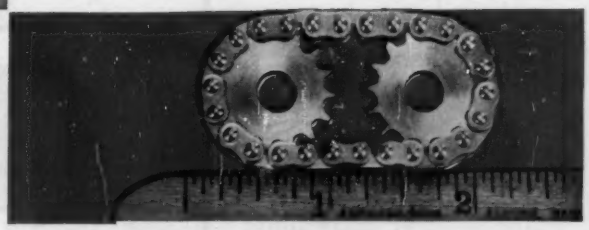

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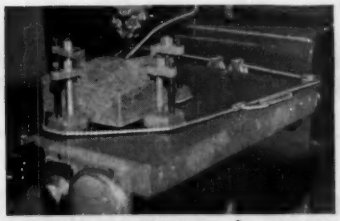
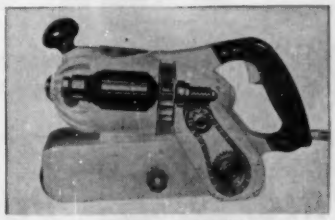
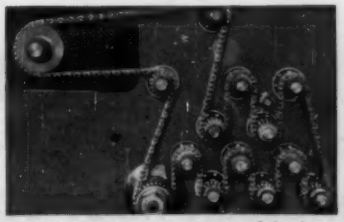


ACCURATE POWER FEED for contour shaping machine is assured by Link-Belt 3/16-in. Silverstreak silent chain.



POSITIVE POWER TRANSMISSION by Link-Belt 3/16-in. silent chain drive aids portable belt sander efficiency.



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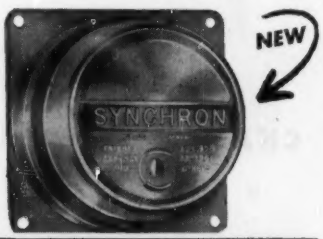

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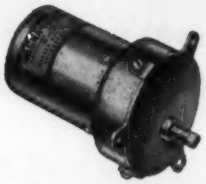

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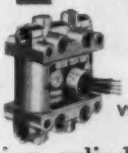
Circle 468 on page 19

25,000,000 CYCLES*

Skinner solenoid valves  are ideally suited for use in high-speed production lines. They perform lubricating, cylinder control, blowing and ejecting functions in hundreds of applications, such as drilling stamping, pressing and riveting. Skinner valves provide fast, dependable and trouble-free operation. They're leakproof, rugged, and *simple to inspect.* Available in more than 100,000 variations, so you're sure of finding the valve that is perfect for *your* particular application.

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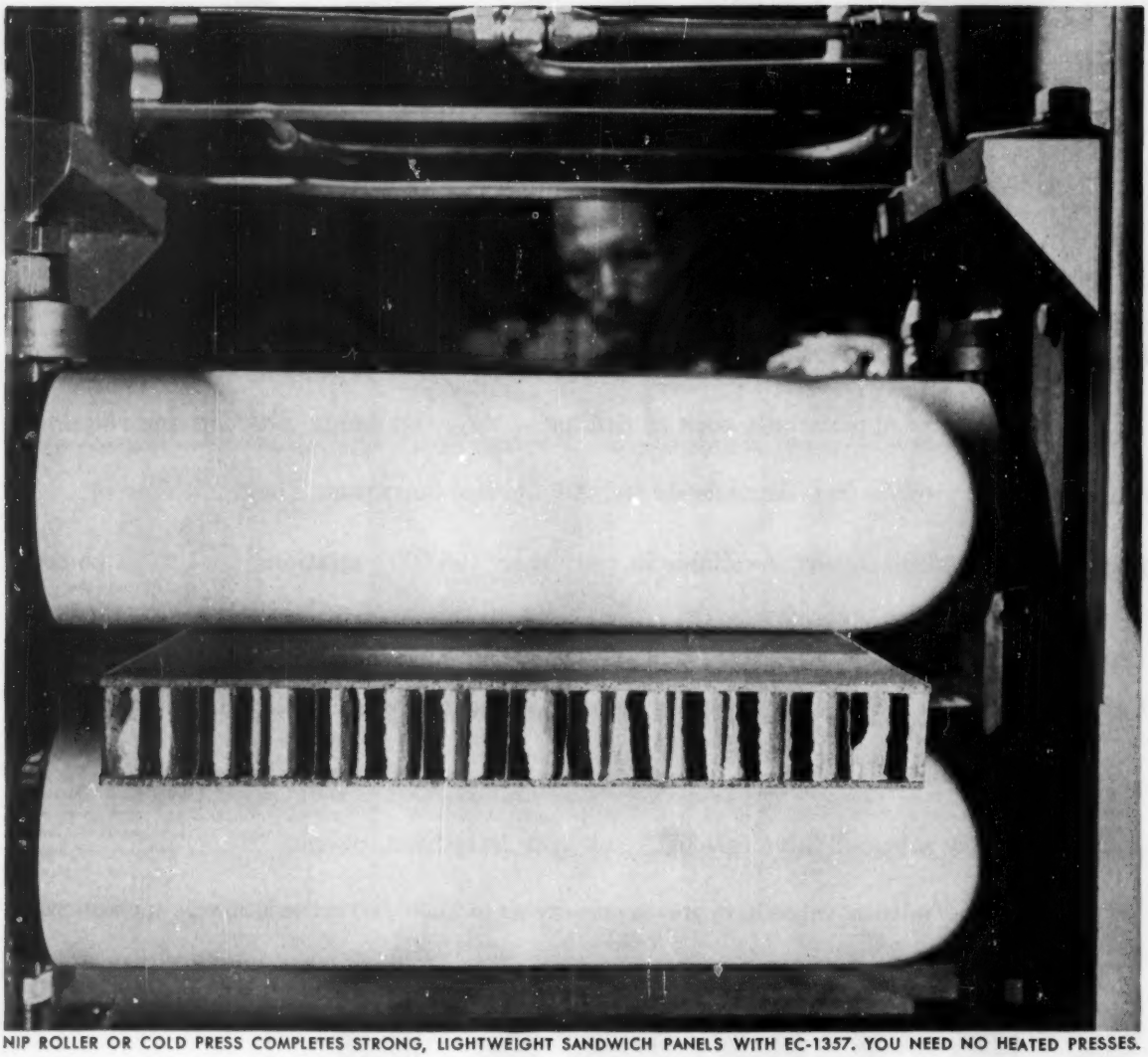
WORLD-WIDE REPRESENTATION

Circle 469 on page 19

For fast, cold sandwich bonding ...3M Adhesive EC-1357



NIP ROLLER OR COLD PRESS COMPLETES STRONG, LIGHTWEIGHT SANDWICH PANELS WITH EC-1357. YOU NEED NO HEATED PRESSES.

Gain the speed and economy of cold bonding! Fabricate sandwich panels for non-load bearing uses with 3M Adhesive EC-1357.

This high-strength, flexible adhesive bonds sandwich panels without clamps or heated presses. You force-dry the solvent out of the adhesive before bonding. Cold press or nip roller finishes the job. You get maximum immediate strength. And EC-1357 builds up even more strength with age as it cures at room temperatures.

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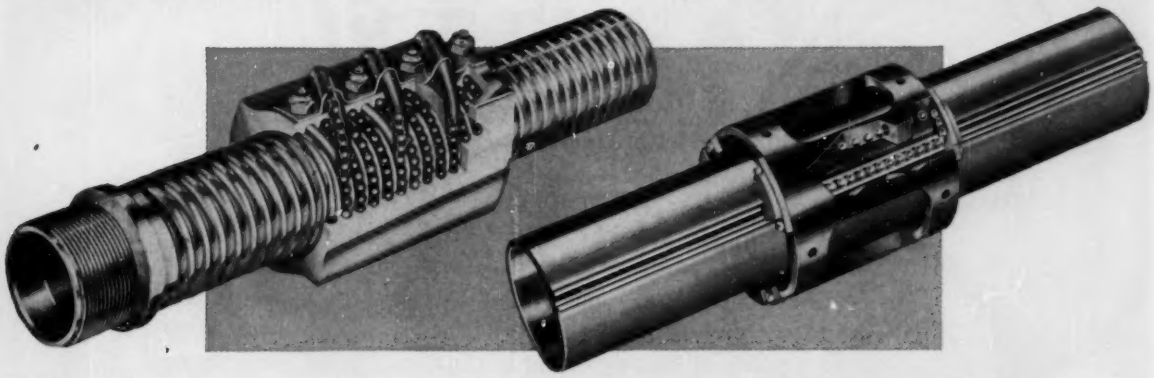
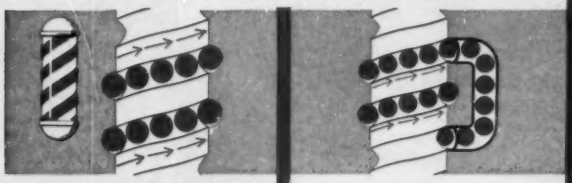


Saginaw b/b Screws guaranteed 90% efficient —offer 6 major advantages for designers

Available in custom machined and commercial rolled thread types—have been built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter.



Nut glides on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅕ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

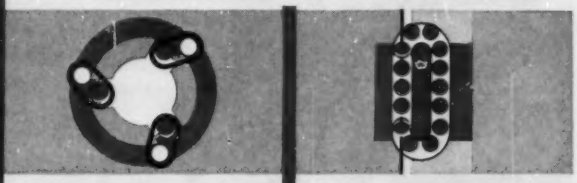
4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

Saginaw b/b Splines average 40 times lower friction coefficient than sliding splines

Transmit or restrain high torque loads far more efficiently—have been built from 3 inches to 10 feet long—⅜ inch to 6 inches in diameter.



The *Saginaw b/b Spline* radically increases the efficiency of transmitting or restraining high torque loads. Instead of *sliding* against each other, surfaces *glide* on rolling balls.

The steel balls recirculate in closed circuits formed by mating longitudinal raceways spaced around the circumference of inner and outer splines. Guides return balls.

This revolutionary new kind of spline utilizes the same basic principle pioneered by Saginaw in the ball/bearing screw.

It permits new engineering designs never before practical—literally lets you achieve the "impossible"! In any application where column length must change under torque load, the Saginaw b/b Spline offers greatly decreased friction, less wear, longer life, more dependable operation. It can be fitted with integral gears, clutch dogs, bearing and sprocket seats or a wide choice of other attachments for use with electric, hydraulic or pneumatic units. To convert push-pull to rotary motion, helical types are available with very high leads, ranging from 20:1 to 100:1.

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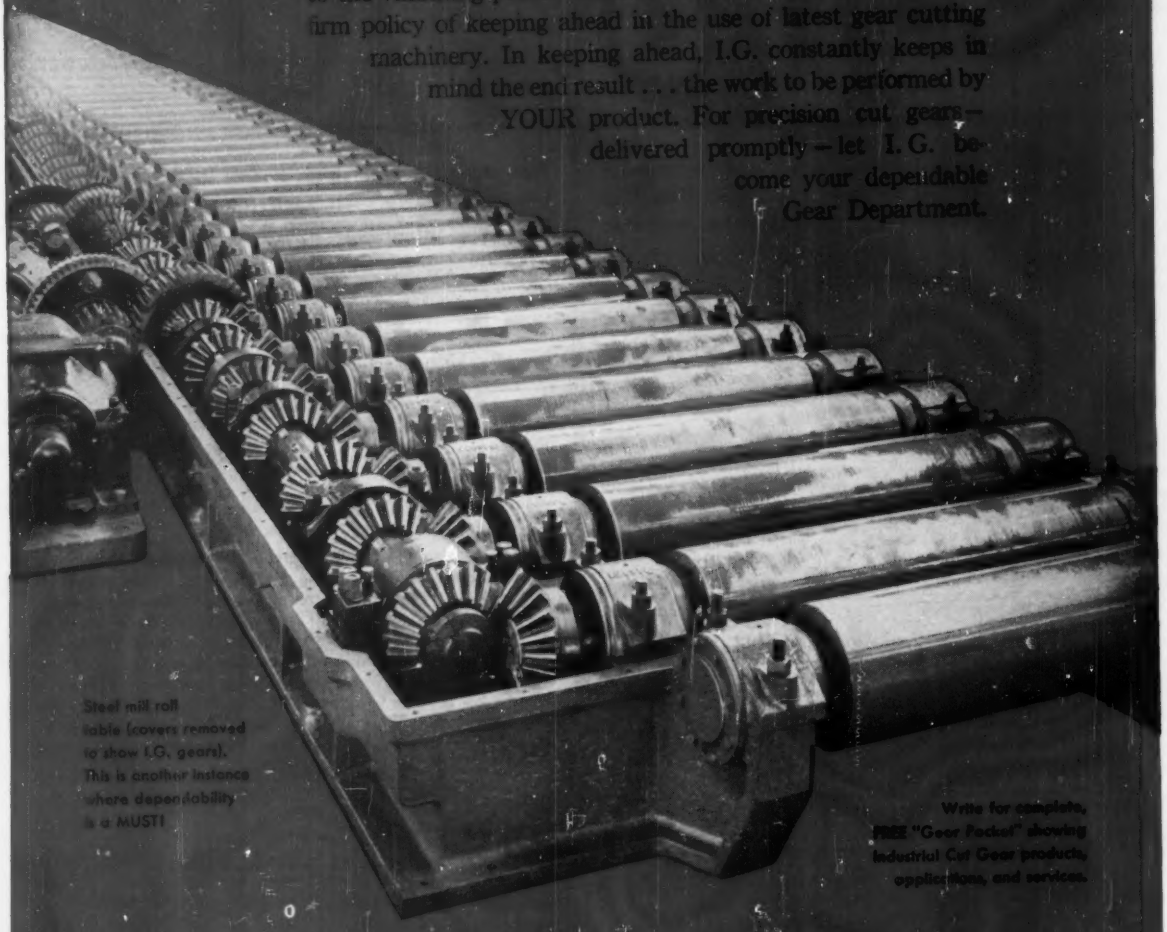

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MACHINE DESIGN
January 10, 1957

Room to Grow

TO BE an engineer you don't have to be queer, but it helps." This favorite jest of engineers and their detractors contains at least a germ of truth. Phil Marvin puts it another way in his article in this issue: conformity has a deadening effect on creative tendencies.

So the engineer who would be creative needs to let the fresh air of originality sweep the cobwebs of conventionality from his mind. How to accomplish this without becoming a "character" is one of the more interesting personal problems of being an engineer.

The free air in which engineering creativity flourishes is a factor which only management can provide. Republic Steel's board chairman, Charles M. White, recently told the ASM: "What might be a pleasant atmosphere to one man may be regimentation to another, throttling his creativity. The creative man needs growing room. He needs recognition as well as pay. He needs to know departmental as well as project goals. Cage him too tightly and his creativity dies."

Growing room—that is the key, whether it is room to outgrow the bounds of convention or room to grow into a broader concept of his job as an engineer. Management can assist the creative process by permitting nonconformity on the one hand and extending the scope of the engineer's horizons on the other.

Colin Carmichael

EDITOR

Engineering the Creative Process

MUCH time is devoted to such subjects as communications, organization and motivation—but if these discussions aren't for the purpose of putting ideas to work, they amount to mere paper-shuffling projects. Many times they are just that because of a shortage of ideas.

Ideas—Reasons for Their Scarcity

Creative thinking is a scarce commodity because there aren't many creative thinkers. Creative thinkers of the past have resulted from a spontaneous process. The shortage of such thinkers will continue as long as the supply depends upon self-stimulation.

Similar problems have been faced in the past. Industry in earlier days depended upon "basement" research and engineering. Management focused its attention on production; industrial activities were production-centered.

Under such a system, production capacity outran the capacity of spontaneous basement research and engineering. Ultimately it became necessary to accelerate research and engineering. Management stimulated development of this function by providing laboratory facilities and by expanding and accelerating the training and development of qualified personnel. The resulting tremendous surge in the output of new products from such laboratories proved the value of stimulating these research and engineering activities.

To increase the output of new ideas, management should take similar steps and focus its efforts in the direction of stimulating an accelerated flow of ideas. The creative process appears to be susceptible to such stimulation.

Studies of this process by competent analysts reveal that while some people may be more creative than others, everyone has creative ability. However, only a relatively few individuals seem to know how to tap their creative potential. Studies have revealed some vitally important aspects of the creative process. While it is recognized that there is a great deal more to learn, tangible results can be achieved by putting to work what is already known about the creative process.

Barriers to Creative Thinking

The first step in developing creative thought processes is one of clearing the tracks of all obstacles to creative thinking. Taking this single step improves the individual's creative capacity by removing barriers to creative thinking.

The barriers to creative thinking fall into three groups reflecting on the individual's power of analysis, social attitudes and emotional responses. Classified under these headings, recognized barriers to creative thinking are as follows:

Analytical Barriers

1. Failure to recognize the problem.
2. Failure to recognize all environment factors.
3. Inclusion of extraneous environment factors.
4. Failure to observe all factors.
5. Failure to associate cause and effect.

Social Barriers

1. Conformity.
2. Co-operativeness.
3. Competitiveness.

Emotional Barriers

1. Unwillingness to dream.
2. Desire to be logical.
3. Fear of ridicule.
4. Desire for security.
5. Superficiality.
6. Wishful thinking.
7. Surrender to novelty.
8. Resistance to change.
9. Distrust of others.
10. Lack of reward stimulus.

These three groups of factors that are classified as barriers to creative thinking exert their influence in somewhat differing ways. One's power of analysis or perceptiveness determines his ability to visualize new concepts clearly and recognize them as such.

Most of us, on occasion, recognize certain innovations as ideas we have already entertained. We rationalize the situation by telling ourselves that we were too busy with other more important matters to take time to act when the idea first occurred to us.

Undoubtedly this is partly true but whether we wish to accept it or not the real truth of the matter

Everyone has creative ability. But, best use of this ability requires a methodical approach to the creative process. There are eight steps:

1. **Establish the problem area.**
2. **Collect pertinent facts and ideas.**
3. **Construct existing relationships in the problem area.**
4. **Develop possible new relationships.**
5. **Incubate.**
6. **Synthesize optimum relationships.**
7. **Evaluate.**
8. **Develop dynamic concepts.**

These steps, along with barriers to creative thinking and desirable background factors for creativity, are discussed in this article.

By Philip Marvin

American Management Association
New York

is often traceable directly to the fact that we didn't recognize the full implications of the idea. Our creative ability was blocked by our inability to properly analyze the situation.

We have considered here the situation wherein we had an already formulated and recognizable concept of an idea. Many ideas remain unformulated and therefore unrecognized because of impairments in our analytical ability. The creative process is blocked because data vitally important to the process were not collected, because extraneous factors were introduced and because proper relationships in the working data have not been established. These ideas never come to the surface.

Analytical limitations represent only one of the barriers to creative thought. Equally important is the social barrier. Conformity, co-operativeness and competitiveness have a deadening effect upon creative tendencies. The conformist, by definition, adheres closely to convention. Such an attitude rarely stimulates a flow of new ideas. In a like manner, the co-operative individual is more likely to acquiesce than to strike out for something new and novel.

The competitive attitude might be regarded as favoring innovation, but competitive tendencies actually limit the individual insofar as innovation is concerned. The competitive individual has a goal which he is desirous of achieving. In striving for this goal, the competitive individual runs the least risk, so he rationalizes, by adhering to the course of action being followed by those with whom he is competing. In this respect he relegates competition to a matter of degree of effort. He may not wish to acknowledge the fact, but he is more certain of his untapped energy than his untapped creative ability.

Social attitudes limit the thought process by channeling it in pre-established patterns. Emotional responses place additional restrictions on creative thinking. Emotional responses take on a great many different forms. For example, one who has been brought up to believe that daydreaming is a waste of time won't be very productive of new ideas until he overcomes that belief. New ideas can take shape only when the thinking process is allowed to run wild.

A logical course of reasoning will reject concepts which don't fit into this pattern of thought. The formal logic behind many good ideas has been developed to defend itself against the embarrassment of a demonstrated fact. Fear of ridicule, desire for security and many other emotional responses similarly limit creative thinking.

No one can ever free himself entirely of all barriers to creative thinking. Recognition of their existence serves as a reminder to check constantly for their presence. Knowledge of the nature of these barriers to creative thinking makes possible continuing self-analysis and mental house-cleaning, thereby clearing the stage for creative thought.

The Creative Background

Creative work has flourished in the presence of specific background factors. Some factors stimulate creative work; others accelerate creative thinking once the process is started. Six factors have been found important in creating a background for creative work:

1. Personal acceptance of inherent creative ability.
2. Broad training and experience.
3. A questioning approach.
4. Acute powers of observation.

5. Capacity for concentration.
6. Ability to associate ideas and facts in new relationships.

One of the essential ingredients of an atmosphere for creative work is the personal conviction that the individual has the capacity for creative work. Almost everyone appears to have some capacity for creative thinking. At the outset this creative capacity must be accepted. It is extremely difficult, if not impossible, to do creative work if one takes a negative attitude with regard to his personal ability in this respect.

Broad training and experience provide both a reference structure of factual knowledge and known working relationships. This greatly facilitates the thinking process. It eliminates time that would otherwise be lost in re-establishing known facts. The absence of broad training and experience generally slows down the creative process, sometimes to a standstill.

A questioning approach is the door-opener in the creative process—it reveals gaps and uncertainties. The greatest catalyst in the creative process is the question "Why?" and a close runner-up is the question "Why not?". Both questions stimulate creative development. Ask them—and it's hard not to start thinking up answers—and you find yourself in the midst of creative activity.

Acute powers of observation supply the working material for creative activity. This is the fact-gathering and fact-verifying mechanism in the creative process. To aid the creative process, powers of observation must be active, accurate and capable of scanning a wide field of vision.

The questioning mind must be capable of quickly visualizing the environment surrounding the problem. Then it must have the capacity to concentrate at will on a single problem of its own selection. The ability to devote full attention to one subject for long periods of time, as required, has been held to be absolutely essential for any markedly creative efforts.

In the course of this concerted effort the individual's ability to associate facts and ideas in new relationships will come into play. Those who have a highly developed facility for reconstructing material in the form of new models will be most efficient in quickly reviewing a large number of potential relationships.

Each of these background factors stimulating and accelerating creative thinking is an integral part of the creative process.

A Plan for Creative Action

No known formula exists to direct creative thought, but an individual plan of action can be developed to put the parts of the process in a certain sequence that has proved helpful. Eight steps are required. At any point in the process it may be necessary to stop and start the process over again. This does not suggest that an error has been made but rather that new knowledge has been developed necessitating a revision or expansion of earlier ground work.

By no conceivable stretching of the imagination can it be anticipated that creative thinking will result as a certainty from any specific course of action. All that can be expected is that creative thinking is more likely to result from a carefully engineered approach. On this premise, careful consideration should be given the role of each of the following eight parts of the overall plan of action.

1. Establish the problem area. The most productive thought process results from efforts centered around a particular problem. Delineation of the problem establishes the area on which attention should be focused. This step should not restrict thinking, but rather spotlight every aspect of the problem on which attention should be concentrated.

2. Collect pertinent facts and ideas. Once a problem area has been selected and defined, it is helpful to collect as much information as possible relating to the problem. Factual data and ideas are both important at this stage of the creative process. This ready availability for quick reference minimizes interruption in the thought process. Interruptions in creative thinking can be costly.

Factual data are essential reference material. Ideas can be equally important. Knowledge of ideas already existing serves both reference purposes and aids in suggesting new concepts and relationships.

3. Construct existing relationships in the problem area. Facts are of primary importance when relationships existing among them are established. Bits of knowledge become usable when we establish relationships between two, or more, pieces of factual data. Ideas are mental mosaics. They are visualizations of useful relationships. A construction of existing relationships puts facts and existing ideas in their most readily available form for reference purposes.

4. Develop possible new relationships. Taking what is known and developing new concepts may be considered to be the only important step in the creative process. It will become immediately apparent that this is not true and that such an attitude slows down creative activity by misplacing emphasis and attention.

Each of the preceding steps has called for degrees of active creative thinking. Positioning the problem in relation to its environment, screening the problem area, selection of factors and orientation are each part of the creative process. If recognition is not given these, the mental process is slowed down. Ultimately, powers of creativity may be shut down.

Developing possible new relationships is a step in applying conscious effort to reassemble facts and ideas into new associations. How many different ways can they be associated? What is the practical significance of each of these different

models? How can they be modified to develop still other relationships? These questions suggest aspects worthy of exploration.

5. Incubate. There comes a time to get away from the subject, to stop application of conscious effort and to forget the whole thing. Let the subconscious mind go to work while conscious thought is turned to other matters. Meanwhile make note of new ideas; otherwise go on to other work.

6. Synthesize optimum relationships. After a time period that will vary with the individual, conscious effort again comes into play. Returning to the problem area, all new ideas should be reviewed and screened to select the best combination of variables. Earlier probing of the subject has probably involved separate treatment of a variety of important facets of the problem. Ultimately these should be fitted together and examined as a whole.

7. Evaluate. A critical look at the idea from a very practical viewpoint is next in order. Up to this point the mind has looked at combinations and permutations of data. Now it asks such questions as: Is it usable? Is it acceptable? How does it fit into the present scheme of things?

8. Develop dynamic concepts. Creative action in the final phase should reshape ideas into vividly portrayed concepts that can be readily interpreted by others. Effective creative thinking is charged with the responsibility for developing ideas that can be communicated to someone else.

In the absence of a specific plan of action, the creative thinking inherent in the solution of a problem can be expected to vary widely. There is no way known to inject a given quantity of the essential ingredient into results. The best thing to do is to approach problems in a manner which has produced the best yield of new ideas.

Engineering the Creative Process

Individual progress is dependent to a very large degree upon ability to inject creativity into daily activities. Yet very little effort is applied to the development of creative ability—an expenditure of effort that holds the promise of sizeable returns.

A profitable starting point for any activity lies in the development of creative ability. This can be accomplished (1) by removing the barriers to creative thinking; (2) by establishing a background for creative thinking; and (3) by approaching problems in a manner designed to bring creative powers into play. All of this amounts to engineering the creative process.

Tips and Techniques

Keeping Scale Positioned

Much time can be wasted hunting the proper scale when a triangular scale is being used. A large spring-type stationary clip clamped to the scale when the correct graduations are in position will serve as a locating device. — EUGENE GESSNER, *Towson, Md.*

Calculating Wahl Factor

In designing helical springs it is necessary to calculate the Wahl factor K, from

$$K = \frac{4C - 1}{4C - 4} + \frac{0.615}{C}$$

where C is the spring index or ratio of mean coil diameter D_m to wire diameter d. The following technique is extremely fast when $C \geqq 6.15$ with a slide rule having CI and DI scales.

1. Align D_m on D scale and d on C scale.
2. Move hairline to 615 on CI scale and read $615/C$ on DI scale. This is the second term.
3. Move hairline to 4 on C scale and read $4C$ on D scale.
4. Mentally perform $4C$-1 and set hairline at this value on D scale. Align $4C - 4$ (obtained mentally) on C scale with hairline. Then slide hairline to 1 on C scale and read answer from D scale at this point. This is $(4C - 1)/(4C - 4)$.
5. Sum the two terms.

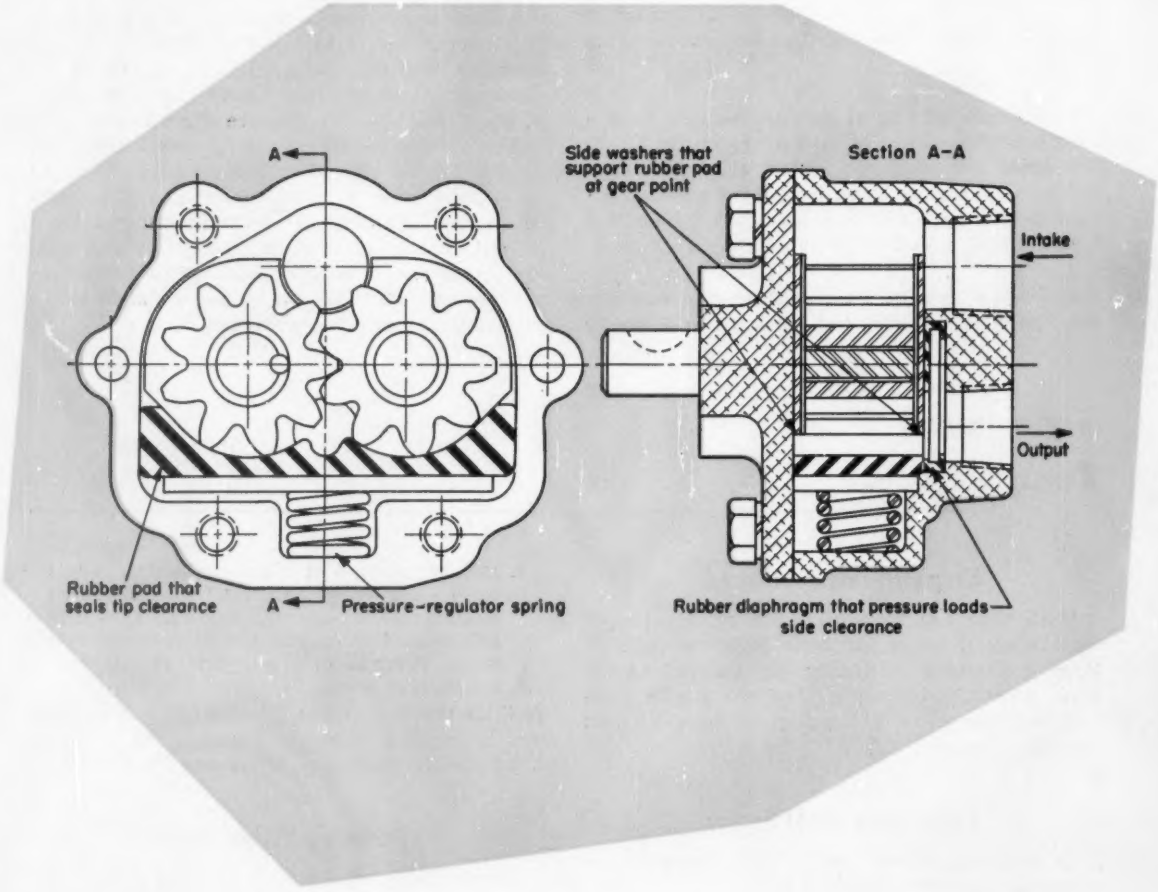
A little practice makes this method quite simple and it requires minimum movement of slide and hairline.—STEPHEN HSU, *Highland Park, Mich.*

Reducing Inking Time

Faster inking can be done by using a Hunt 107 pen for fine lines, a No. 5 Henry Tank pen for medium lines and a No. 15 Henry Tank pen for heavy lines rather than the conventional ruling pen. These points are used in ordinary penholders and are, therefore, much more convenient to use than a ruling pen. Quality of the work is equal. Only limitation is with extremely small holes in templates.—A. E. TAMER, *Western Electric Co., Lawrence, Mass.*

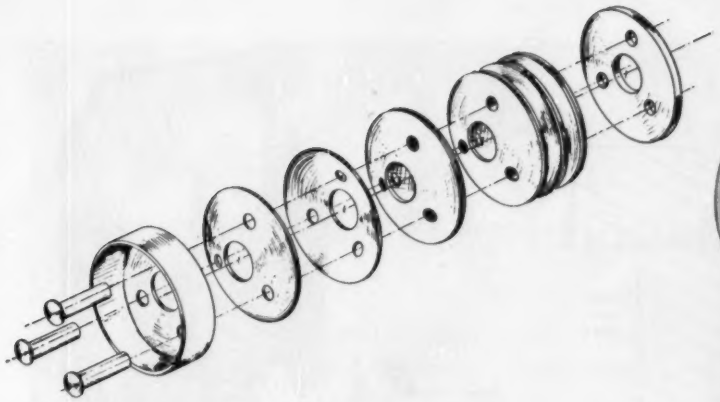
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

scanning the field for *Ideas*



ACCURATE CONTROL OF OPERATING CLEARANCES in a gear pump is achieved by a flexible, movable housing design. A molded synthetic-rubber pad conforms with zero clearance to the tips of the gear teeth along the pressure-outlet side of a pump developed by the New Products Corp. This tip-clearance pad is held in place against the tooth tips by a spring, which will allow the pad to act as a relief valve at a certain maximum pressure. In addition a molded synthetic-rubber diaphragm is installed under the two gears. This diaphragm, which is automatically inflated by fluid pressure, takes up clearance between the upper and lower faces of the gears.

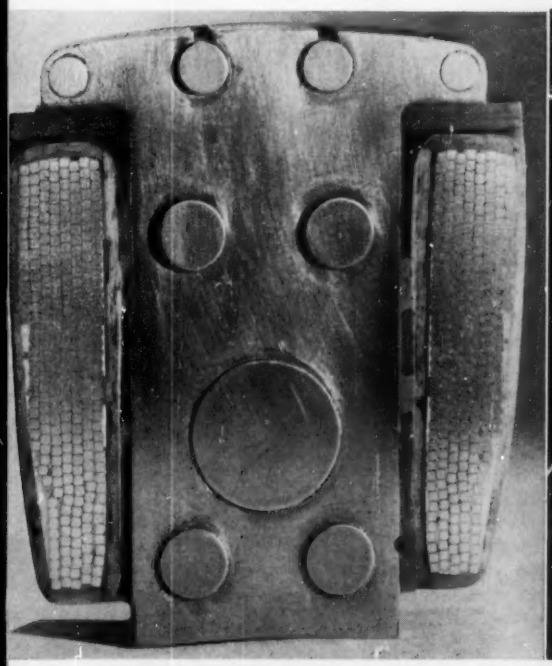
The design permits larger tolerances in the gears, which can be hobbed, rolled or made of metal powder.

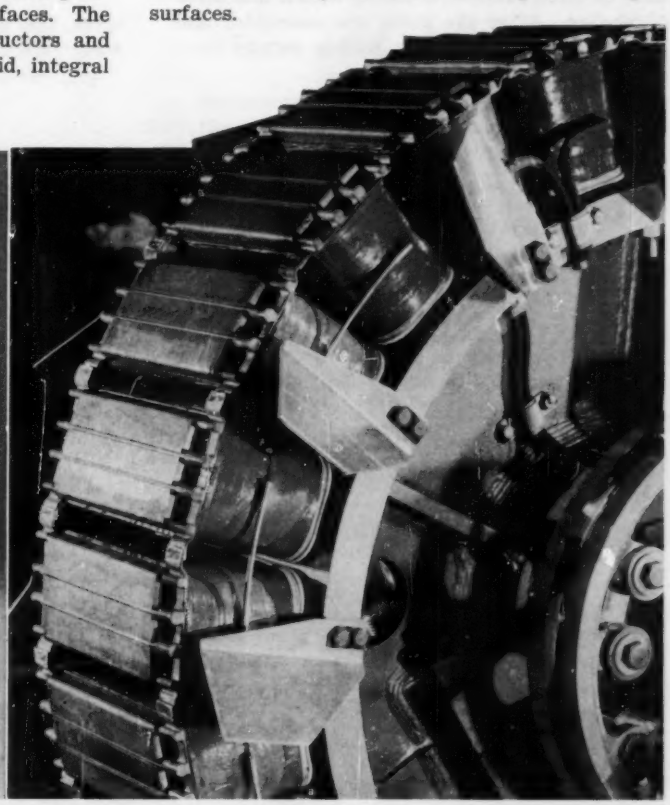


BELLEVILLE-WASHER STACKS permit easy handling of a large number of spring washers and assure proper orientation in assembly. The washer cartridges, which are held together by pins or rivets passing through the washers at or near their neutral axis, can be preloaded, allowing easy assembly in a machine with a small additional compression force. Developed by the Associated Spring Corp., the units are loaded at three points or more to prevent buckling of the stacks.

PLASTIC LOCKING of field coils to salient poles in Allis-Chalmers motors and generators minimizes maintenance problems that can develop from mechanical vibration and thermal shock. In construction, a resin-reinforced glass-fiber laminate is employed to cover the coils which are in turn pressure molded directly to rotor pole surfaces. The resins bond tightly with the coil conductors and pole surfaces to form an essentially solid, integral unit.

The design method is equally suitable for pole and form-wound coil types. Form-wound coils are processed complete, off the pole, and then cast-in-place on the pole with an insulating resin. Pole-wound coils are shaped on the pole and bonded by the resin-filled glass fibers directly to the pole surfaces.





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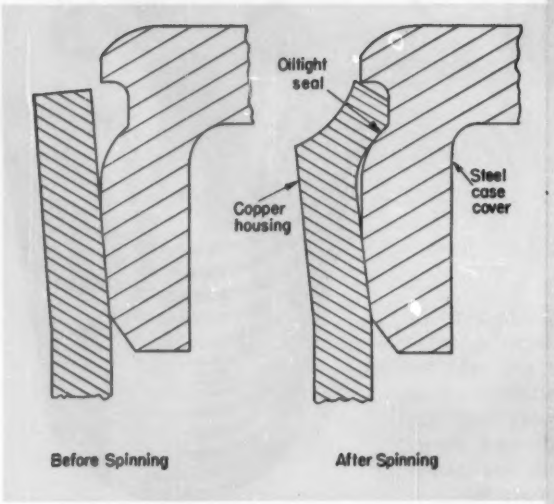
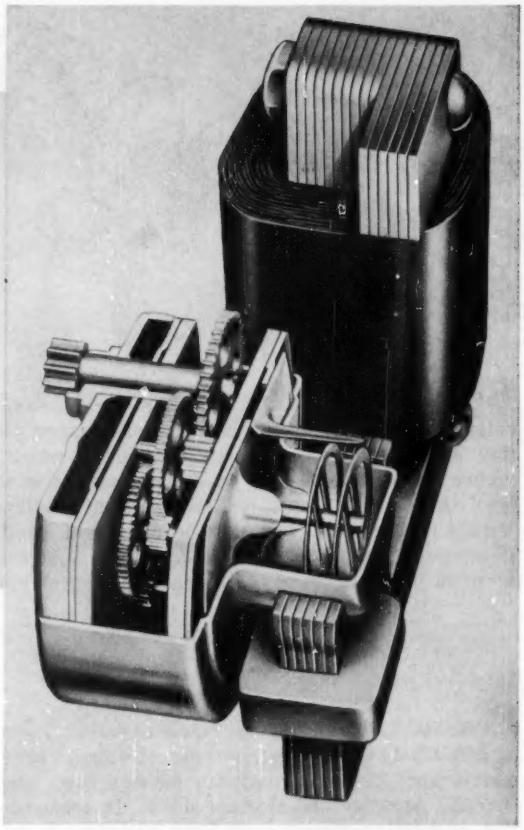
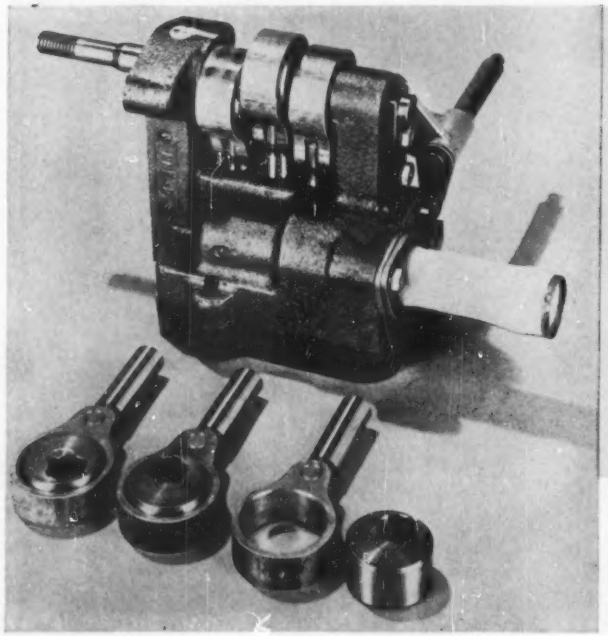




OILTIGHT SEALING OF MECHANICAL ASSEMBLIES by means of spun-on housings simplifies fabrication problems. The design technique is used to seal a copper case shell around the rotor and gear train of a General Electric-Telechron clock type synchronous motor. The seal is maintained between the inside diameter of the copper case shell and the outside diameter of the steel case cover. Prior to assembly, each of these surfaces is coated with a thin layer of shellac. After the parts are assembled and heated, a special machine with a rotary head spins the copper case shell tight against the steel case cover to form the seal.



SLICED-CASTING DESIGN facilitates production of small mechanical elements. In a technique reported by American Smelting and Refining Co., combination connecting rods and bearings for oil pumps are cut from long, continuous-cast bronze castings which have a special keyhole shape. The design offers improved strength characteristics and eliminates short-end scrap.

Do you have a novel design idea for our other readers? You can receive ten dollars or more for each idea accepted for exclusive publication in this department. Send a short description plus drawings or photos to: "Scanning the Field for Ideas," MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Permanent Employment Contracts

. . . fundamental facts about valid lifetime agreements

By Albert Woodruff Gray
Forest Hills, N. Y.

BY dictionary definition "permanent" is fixed, unchanging and enduring. By definition of the United States Supreme Court 60 years ago, "The word 'permanent' does not mean forever, or lasting forever or existing forever. The language used is to be considered according to its nature and its relation to the subject matter of the contract."

Contracts Terminable at Will

Before the Federal Court of Appeals for review recently was the decision of a lower court denying a Wisconsin engineer a recovery for what he claimed was a breach of contract for his permanent employment as plant engineer for an Illinois radio parts manufacturer.

His agreement, which had been oral, was that he would receive $10,000 a year and one half of one per cent of the gross sales and have the position of plant manager in charge of this branch of his employer's business. In sustaining the judgment in favor of the employer, the court said of the engineer:

"He had a right to terminate his employment at any time and did not promise to perform for any definite length of time. Therefore the contract could not have been enforced against him and was lacking in mutuality. Consequently he cannot enforce it against the employer.

"He is in no better position if we consider the alleged agreement from the point of view of its term of existence, for the period of its continuance is indefinite. It is a contract at will which may be terminated at the option of either party at any time.

"Nor can it avail him that his contract was, in his own words, permanent. The Supreme Court of Illinois has expressly held that a contract for permanent employment is one at will. This is in accord with the decisions of other jurisdictions that contracts not expressly made for fixed periods may be terminated at the will of either party."

Form of Consideration

A controversy of the same character came before the Supreme Court of Connecticut. There, with the same conclusion, the court said of contracts for permanent employment, "In the absence of a consideration in addition to the rendering of services incident to the employment, an agreement for permanent employment is no more than an indefinite general hiring, terminable at the will of either party without liability to the other."

Giving up one job to take another has been judged insufficient consideration for making the second job a lifetime position.

In a suit against his previous employer for breach of contract, an employee maintained he had been hired under an agreement for permanent employment, and as a consideration for this contract he had left his previous employment.

Judgment was directed by the court denying the employee a recovery with the statement, "The employee argues that he suffered a detriment by giving up his job. To constitute sufficient consideration for a promise, an act or promise not only must be a detriment to the promisee but must be bargained for and given in exchange for a promise. The mere giving up of a job by one who decides to accept a contract for alleged life employment is but an incident necessary on his part to place himself in a position to accept and

perform the contract. It is not consideration for a contract of life employment."

Rejecting one job offer in favor of another was held to be insufficient consideration for a permanent contract in the case of a consulting engineer who turned down an assistant professorship at a leading university to work for an industrial concern. He was discharged two years later. In denying the engineer's claim, the court said, "The effort of this employee to show an additional consideration passing from him to his employer was abortive, since it shows that he merely abandoned other activities and interests to enter into the services of this manufacturer—a thing almost every desirable employee does upon entering a new service, but which, of course, cannot be regarded as constituting any additional consideration to the employer."

Mutual Obligations

In contrast to the application by this court of the law in circumstances of this character is another incident that occurred a few years ago in Arizona. Instead of the salaried employment contract under which he had worked for 20 years, an engineer agreed to accept a smaller but definite sum each month and to hold himself available as a consultant with the privilege of accepting work of this type from other sources. This agreement was to continue for life.

After five years the company refused to continue the agreement, and an action was brought by the engineer against the company for the breach of this life employment contract. The court sustained the engineer's contract as valid and enforceable. "Such a contract," it was said, "has been referred to as one in which there are reciprocal promises so that there is something on both sides to be done or foreborn. It is a promise for a promise, that is, one in which there are mutual promises between two parties to the contract.

"In such a contract mutual obligations are requisite and the promise which one makes is a sufficient consideration for the promise which the other makes. The mutual promises of the parties will constitute a sufficient consideration for a valid agreement, but where there is no promise on the part of one of them as a consideration for the promise of the other, there is no valid contract."

Expression of Intent

The Federal Court of Appeals has said of the necessary features for a valid permanent or lifetime employment contract, "The rule is that unless the parties reveal an intent to enter into a contract for permanent employment it will be regarded as terminable. Where the intent is not clearly revealed by the express terms of the agreement, the courts will look to evidence of surrounding circumstances to determine what was in the minds of the contracting parties.

"If it is their purpose the parties may enter into a contract for permanent employment — not terminable except pursuant to its express terms —by stating clearly their intention to do so, even though no other consideration than services to be performed is accepted by the employer or promised by the employee."

Then of the usual instances in which these so-called permanent employment contracts have been held void and unenforceable, the court added, "Where no such intent is clearly expressed and absent evidence which shows other consideration than a promise to render services, the assumption will be that — even though they speak in terms of 'permanent' employment — the parties have in mind merely the ordinary business contract for a continuing employment, terminable at the will of either party."

Valid Contract Agreements

Contracts for enduring and lifetime employment are, however, often sustained by the courts. Such agreements, however, invariably stipulate clearly and unequivocally this feature in terms unmistakable to either party.

A man who was injured in his work agreed to a written contract, proposed by his employer, providing for his employment for life or for such time as he was able to continue his work, at the same pay or better than he had received in the past. Two years later the man was discharged.

In its decision that here was a lifetime employment agreement the court said, "We have no doubt that the employer could obligate itself to furnish the employee for life with such work as he would be capable of performing in his disabled condition and to pay him wages so long as he was able to render services, and that his promise to remain in this employ and render the required services would be a sufficient consideration to support the obligation.

"The rule is that a contract for lifetime employment will be given effect according to its terms if the intention of the parties to make such an agreement is clear, even though the only consideration for it so far as the employer is concerned, is a promise by the employee to render service called for by the contract.

"Where the words 'permanent employment' are used in a contract of hiring and it is not clear from the language of the contract or from the circumstances surrounding the making of it, or from the consideration furnished, that the parties intended that the employment was to continue for life or while the employee could render services as required or the employer furnish the employment, the contract will be construed to be for an

indefinite period and terminable at will by either party."

If this feature of a continuing and lasting employment is to be upheld, the distinction from the usual employment agreement must be clearly expressed. Frequently the determining factor has been asserted by the courts to be the presence of an additional consideration on the part of the employee for the benefit of the employer. However, in a recent New Jersey case the court pointed out that this "additional consideration" so frequently mentioned by the courts was simply set up as a test of the intention of the parties:

"The rule which speaks of 'additional consideration' beyond the mere agreement on the part of the employee to render service, as a requisite to support a contract of life employment, is merely a device created by the courts to test whether or not the parties specifically and definitely intend to make such a contract.

"Assuming the legality of the subject matter, there is no reason why two understanding persons bargaining at arms length cannot make an agreement contemplating life employment so long as they clearly and unequivocally state their intention to do so.

"Basically what the courts are saying when they declare that some additional consideration beyond the promise to render service, must appear to support a lifetime employment contract is, that where such unusual contracts are sued upon the intention of the parties to make such a compact must be established clearly, specifically and definitely."

Agreements for employment of this character that fail to set out their purpose "clearly, specifically and definitely," must fall within the condemnation expressed long ago by a Mississippi court, that has since, to some extent at least, been softened by later decision.

"With regard to the theory of perpetual duration, little need be said. Perpetual contracts of this character will not be tolerated by the law, or rather, will not be enforced as imposing an eternal and never ending burden.

"An agreement to furnish a support, or service, or a particular commodity at a specified price, or to do a certain thing without specification as to time, will be considered as terminable at pleasure or as implying that the thing to be done shall be performed within a reasonable time and the obligation will cease within the same limitation.

"Any other theory than this would subject incautious persons — a class it may be remarked which includes a majority of mankind — into lifelong servitudes and greatly fetter and embarrass the commerce of the world."

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2. Meadows v. Radio Industries, 222 *Fed.* 2d 347
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4. Fisher v. Jackson, 118 *Atl.* 2d 316, Connecticut
5. Skagerberg v. Blandin Paper Co., 286 *N.W.* 872 Minnesota
6. Abbott v. Arkansas Utilities Co., 165 *Fed.* 2d 339
7. Littell v. Evening Star Newspaper Co., 120 *Fed.* 2d 35
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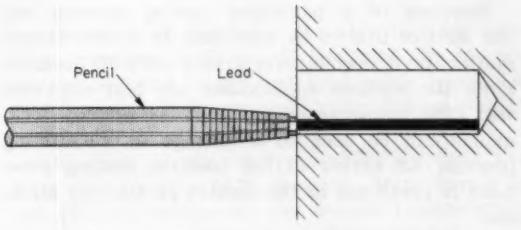
Tips and Techniques

Depth Measurements

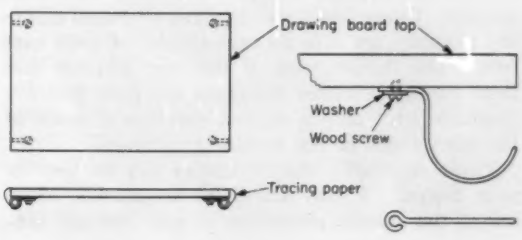
Occasionally when designing or detailing, it is necessary to measure an existing piece. A clutch-type draftsman's pencil makes an excellent depth



gage if the real thing is not available.—W. A. KNOLL, *Frank Mayer Engineering Co., Los Angeles, Calif.*

Holding Long Tracings

Wire brackets bent from an ordinary coat hanger may be attached to a drafting table as shown to keep either or both ends of a long tracing from hanging down and becoming smudged or torn. When position of the tracing must be changed, it is only necessary to roll the tracing a little more at the appropriate end. The other end will unroll easily.—ROGER ISETTS, *Kenosha, Wis.*



Designing Gray Iron Castings

Basic methods and principles for design of low-cost parts in gray, alloy and nodular cast iron

By Arthur Scharf
Mechanical Engineering Div.
Battelle Memorial Institute
Columbus, O.

and

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Technical Director
Gray Iron Founders' Society
Cleveland

A CASTING may be defined as a piece of metal in a useful shape, formed directly from the liquid state by solidification in a suitably shaped mold. Over the years, casting techniques have been developed to reproduce the desired design dependably and accurately with almost no limitation as to complexity. More complex shapes are often only a little more expensive to cast than simpler shapes. Thus, the designer has freedom to design for greatest function, even though there may be complex sections of varying thickness, styling shapes, curved brackets, shrouding, bosses, or other useful elements.

Castings made of gray iron have, in addition to the general advantages of all castings, the benefit of certain favorable casting characteristics. These are the ability to flow as molten metal in very thin sections, solidification with little shrinkage, a minimum of internal stresses in the casting, good machinability, and relatively low cost. Intricate castings with good finish are routine. Modern foundry methods provide closely controlled quality. Dimensional stability and optimum damping capacity are also useful qualities of gray cast iron. The development of the new nodular cast irons has made higher strengths and good ductility available with only a modest sacrifice in some of the advantages of the regular gray irons.

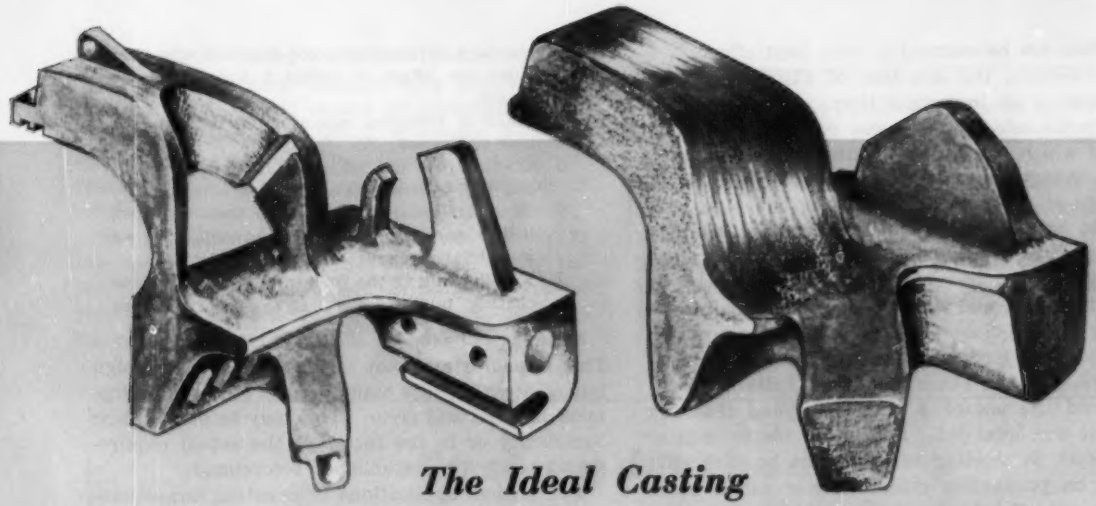
These favorable characteristics can be lost by poor design. A less functional design will result unless the specific properties of cast iron are considered. This article will discuss what is "good" design in iron castings.

Casting Methods and Foundry Facilities

There are several divisions or classifications within the foundry industry. A foundry may be identified by the kind of metal that is poured, the kind of molds that are used, and by the pouring forces utilized (i.e., gravity or centrifugal). Foundries may also be classified by the kind and size of castings that they make, by the degree of mechanization employed, and by their typical order quantities. Most foundries will come under more than one category.

Selection of a particular casting process and the kind of iron to be used may be a very simple matter, or it may involve a very difficult decision. Even the obvious applications are best discussed with the foundryman, since many special techniques can be used to advantage in the casting process. A review of the common casting processes is presented in the section on *Casting Methods*.

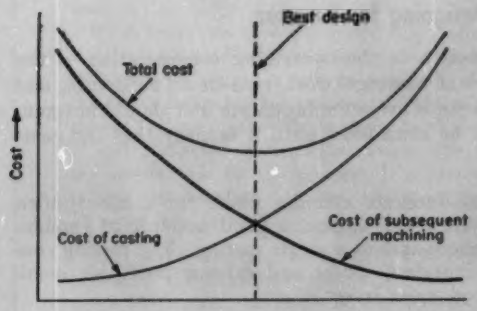
A recent trend in specialization among foundries has provided facilities for specific types of castings. Some foundries are best equipped for high rates of production, while others can more effectively turn out single or experimental castings. Increas-



The Ideal Casting

From a designer's viewpoint | **From a foundryman's viewpoint**

As with almost all engineering, a "good" design for an iron casting is usually a compromise. Neither of the extreme views represented above is "right"; the designer's ideal casting would be almost impossible to cast, and the foundryman's ideal would be extremely costly to machine.



For a given design, there is usually some optimum point on the cost curves which represents the "best" design from a cost standpoint. The curves might look something like those at left, where the left side represents an easy-to-cast, hard-to-machine casting, and the right side is a difficult casting with little subsequent machining.

Cost is not the only criterion. Strength and deflection considerations, appearance, vibration and environment may all influence a design decision.

Purpose of this article is to provide the fundamental facts and principles for engineering a "good" design in cast iron. The article is based on a chapter of *The Gray Cast Iron Handbook*, to be published soon by Gray Iron Founders' Society Inc.

ing numbers of foundries are able to offer complete technical facilities. Evidence of this specialization is found in the fact that many companies which operate their own foundries purchase certain castings from other foundries.

One phase of the modern foundry's growth has been the expansion of its services. Many foundries are prepared to accept the overall responsibility for the casting. This often includes helping in the design, making trial castings, specifying the pattern equipment, and recommending the proper heat treatment if necessary. Some foundries are equipped to give the castings a comprehensive inspection, special finishing, and preliminary machining or targeting in a locating fixture to provide an accurate setup for machining. With this complete service, castings are ready for production machining as received.

The foundryman can advise on selection of the particular grade of iron to be used and on details of design which will facilitate casting. He can plan his molding practice to avoid the marking of critical faces with gates, and to ensure the holding of necessary tolerances. Although ample time for discussion of the design should be allowed to permit desirable modifications, the overall develop-

ment time can be reduced by this joint effort.

For example, the selection of suitable pattern equipment is an important item. Several factors influence the selection of proper pattern equipment, some of which involve the casting purchaser. Are design changes anticipated? What is the probable rate of production? How long is the pattern likely to be used? What degree of finish and accuracy are necessary? In a similar manner, the foundryman will be concerned as to how he will make the molds, and what machines and equipment will be used. Surprisingly, even an extremely crude pattern is often successful for experimental work. On the other hand, it is false economy to extend the use of a pattern beyond that for which it was intended. Patterns made to require hand work in molding often cannot be used efficiently on production machines, nor can a casting be expected to be more accurate than the pattern equipment from which it was made.

Casting Design Procedure

Castings may be divided into two types when considering the techniques for their design from a strength standpoint. First, there are those applications in which the working stresses are so low that the casting sections are determined by the functional shape, by the appearance, by clamping loads during machining, by assembly pressures, and by castability requirements. The experienced designer can often establish merely by inspection which castings fall into this group. The design of such castings is largely an art based on a knowledge of the product being designed. The emphasis is on producibility and appearance.

The second type includes castings in which failure could result from service loading because of high static, impact, or fatigue stresses. These more advanced applications need individual and systematic analysis to obtain economical and dependable design. The uniform assumption of a certain "safe" working stress, as common in the past, is a poor practice. Unless this value is set so low that most of the castings are uneconomically overdesigned, some castings will be marginal in strength. In many casting applications, wear, corrosion or heat-distortion resistance, or other nonmechanical properties are also important requirements. Some of these, such as electrical resistance, may be calculated from numerical data. The ability to meet other requirements, such as wear resistance, can best be established by reference to the wealth of practical experience available.

The following preliminary design sequence is intended primarily for more involved castings, although a number of the steps are also applicable for less demanding designs.

1. From the layout and overall specifications, established the service conditions for the casting.
2. Determine static and dynamic forces, and the other critical requirements.
3. Lay out the structural skeleton to determine the best arrangement for function and consider the effect of points 1 and 2 on this layout.
4. Make a tentative selection of the type of iron to be used.
5. Check stress and deflection, if these are critical, and evaluate the tentative selection.
6. Consider general appearance from point of utility and sales appeal, or consult with an industrial designer on these points.
7. Finally, talk to the foundryman to determine casting quality, cost, and delivery before locking in the design.

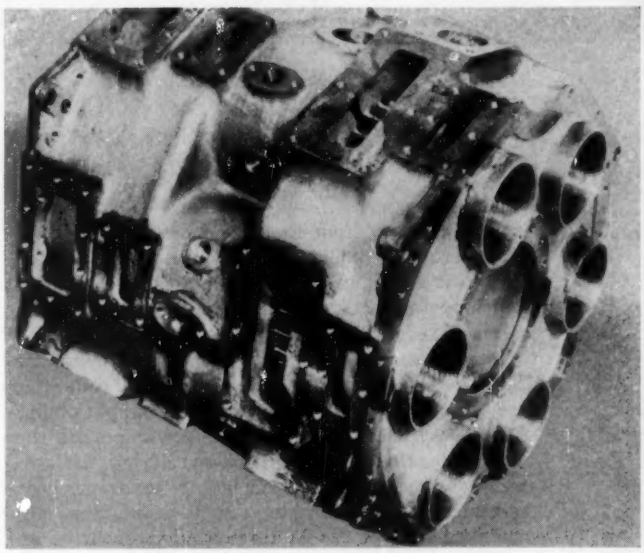
This sequence may not yield a production design immediately because many designs require development by trial and error. This may be due to their complexity or to the fact that the actual requirements can not be established beforehand.

For critical applications or eventual large-quantity production, experimental castings are first subjected to laboratory and field tests. The use of brittle lacquer and strain gages is of valuable assistance in the design for stressed applications. The necessary modifications in design, foundry practice or specifications are then made, and the revised castings are checked again. The final production design and material specification thus incorporates the initial design analysis and the results of the trial work.

Designing for Function

Function is the overriding consideration in the design of castings. Cost, ease of manufacture, and appearance are all subordinate and should not generally be considered until it is clear that the cast-

Fig. 1—Intricate cylinder block for a six-cylinder, two-cycle diesel engine, a good example of combining functions into a single casting. The casting contains cylinders, intake and exhaust ports, air manifold and water jacket.



ing will do the job for which it is intended.

In the preliminary analysis of a problem, the primary consideration should be performance. If an apparently complicated or expensive design is indicated, it should not be rejected as being impractical until an overall appraisal can be made of total cost versus value.

The first step is to study the part in relation to the assembly. In a static structural part, the points of loading are identified, with the special relationships established. Layouts are made showing all the external connections, and the proposed parts are sketched in. The goal is to achieve the most direct transfer of loads, subject to clearance limitations.

With hydraulic machinery, there is primary emphasis on the paths of fluid flow. The hydraulic circuit is established and the passageways drawn. The structural housing then follows, with the mounting faces conforming to the installation requirements.

In general mechanisms, first consideration is

Casting Methods

Green Sand Casting: This is the most widely used molding method. It utilizes a mold made of compressed moist sand. The term "green" denotes the presence of moisture in the molding sand and that the mold is not dried or baked. This method is generally the most expedient, but it is generally not suitable for large or very heavy castings.

Dry Sand Casting: Most large and very heavy castings are made in dry sand molds. The mold surfaces are given a refractory coating and are dried before the mold is closed for pouring. This hardens the mold and provides the necessary strength to resist large amounts of metal, but increases the manufacturing time.

Molds which are hardened by the CO_2 process may also be considered in this category. Such molds are not dried, but are made from an essentially moisture-free sand mixture which contains sodium silicate (water glass). The mold is rapidly hardened by the reaction of carbon dioxide gas with the silicate. The process can also be used for making cores. It is advantageous in reducing manufacturing time, but is not practical for some types of work.

Shell Mold Casting: This method is of recent development and utilizes the unique process of making molds by forming thin shells of a resin-bonded sand over a hot pattern. It is suitable for small and some medium-sized castings. Shell molding provides improved accuracy and surface finish. It allows for greater detail and less draft than is normally satisfactory in green sand molding. Metal patterns of special construction are necessary. The process is of particular advantage when it provides savings in machining and finishing the casting. The shell process has also been very effectively applied in making cores, which may be used with any of the molding methods.

Core Mold Casting: Castings of unusual complexity (such as the thin and deep fins of an air-cooled engine cylinder) may be produced in a mold made of the type of sand commonly used for cores. This sand has almost free-flowing properties when it is packed around the pattern, and it will fill crevices and reproduce detail. After baking, the mold becomes strong enough to resist the forces of flowing molten metal. Core-sand molds may be used when complexity requires more than one parting line in a casting. Core-sand sections may be used to form a complex external portion of a casting in either a green or dry sand mold, just as cores are used to form internal surfaces.

Permanent Mold Casting: Iron castings, within limits as to size, complexity, and properties, can be produced in large numbers from mechanically operated permanent iron molds. This mechanized, high-production process is mainly used for castings of suitable shape, of less than 25 lb weight, and with 3/16-in. minimum wall thickness. Coring is accomplished with conventional sand or shell cores.

Ceramic Mold Casting: Certain highly specialized castings requiring an unusually fine finish, precise detail and close tolerances are produced in molds made of fired ceramics. This is comparable to the plaster-mold process which is used for nonferrous alloys. Pattern equipment is generally of a "core-box" type, and may be made of metal or plaster. In some applications, backdraft or undercuts are allowed by making part of the pattern of a flexible material. When the mold can be assembled from a number of pieces, castings of several hundred pounds in weight and several feet in a major dimension can be made to relatively close tolerances.

Expendable Pattern Casting: This is a form of ceramic molding and is more popularly known as "investment" or "lost wax" casting. A pattern of wax, plastic, or frozen mercury is made for each casting desired. After investing in a refractory mold, the pattern is removed by melting or burning it out. No consideration for draft or a parting line is necessary, since the pattern may be formed by assembling a number of parts. Investment castings may be produced with excellent finish, detail, and to close tolerances, but the process is generally limited to small castings.

Centrifugal Casting: Most molds are filled with metal simply by the force of gravity, but centrifugal force may be used in two ways. True centrifugal casting is a means for producing a cavity in the casting without the use of a core. The production of pipe by this process is well known, but the method is also used for making many other cylindrical castings, from engine cylinder liners to large process rolls. Secondly, centrifugal force may be used as a means of forcing metal into a mold. This is of practical application in pouring ceramic molds of small castings with fine detail, where the high surface tension of the molten metal and the low permeability of the mold material may not allow complete filling of the mold by gravity alone.

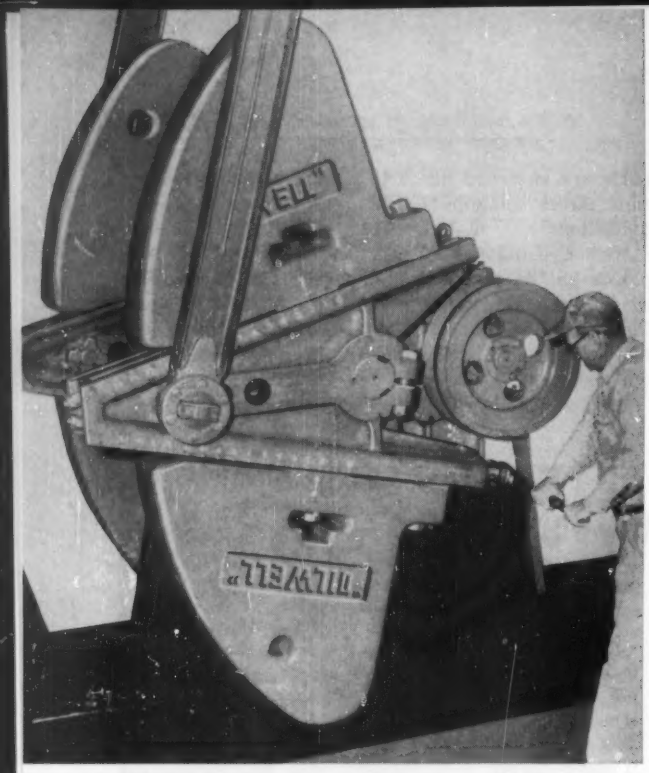


Fig. 2—Cast counterweights and slides on pumping equipment, a functional design with integrally cast T-slots and calibrating scales.

given to the linkage. After a kinematic analysis, the individual links are drawn. The base and auxiliaries then follow.

The casting in Fig. 1 is a good example of combining a number of functions into a single compact unit. This piece is a cylinder block for a two-cycle diesel engine. It contains six cylinders serving twelve opposed pistons which operate on a two-cycle basis. All cylinders with their intake and exhaust ports, air manifold, and water jackets are included in the single casting. An alternative design using separate cylinder units would call for at least five machined "stepped" joints for each cylinder. The machining cost of this cylinder block with separate cylinders would be very much greater than that involved in the integral cylinder construction.

Ports must have smooth walls and be accurately located with respect to longitudinal position. These ports are also located symmetrically with the radial line through each cylinder, so that all intake and all exhaust ports are identical. This reduces the amount of precision pattern equipment necessary. All openings from the water jacket and port cores are arranged on the sides of the block with none showing on the end. This design avoids possible difficulty with a seal at the ends of the block.

Another interesting example of functional casting design is the adjustable counterbalance equipment used on oil-well pumping equipment to compensate for load variations in pumping operations, Fig. 2. The one-piece counterweight can be moved along calibrated slide rails by turning an Acme screw and then locking with T-bolts. The inclined rails permit the maximum counterbalance torque to be supplied with given weights in a given overall crank diameter. The integrally cast scale makes it possible to obtain tabulated values of counterbalancing.

Cast iron is a logical choice where weight is important for stability, because of the low cost of iron in a given casting. It is used to lower the center of gravity of mobile equipment, to increase weight to prevent sliding, and to counterbalance moving or rotating parts. These masses can be made very economically in cast iron, with the further advantage of molding a shape to suit the space available. The greatest economy is obtained when these masses are incorporated as an integral part of the machine body. Crankshafts are an important application of this technique.

Designing for Strength and Performance

When cast iron is indicated by the function of a part or by its intended service, one of the numerous types of cast iron must be selected. This selection should be regarded as a first approximation, subject to discussion with the foundry engineers.

Types of Cast Iron: Cast iron is a generic term that identifies a family of high carbon-iron-silicon alloys which have evolved from the original single material. The wide variety of commercially available cast irons may be considered under three general types. A fourth type, malleable cast iron, is the product of another division of the foundry industry.

Gray Cast Irons: Gray irons are usually classed according to their ultimate tensile strength in a range from 20,000 to 60,000 psi minimum. Though primarily for structural purposes, gray iron is used in a large number of applications involving moderate corrosion, heat or wear resistance. The traditional gray or cast iron which is otherwise unspecified comes under this heading in the lower strength ranges. It is the most commonly used type because of its ready availability, moderate cost, and suitability for both simple and very complex castings.

Alloys such as nickel, chromium, molybdenum, and vanadium may be added to develop or enhance the desired properties. The alloy content may be specified for castings in heat or corrosion resisting applications, since these properties are difficult to establish other than by actual use. The general engineering grades of gray iron can be specified most conveniently by reference to American Society for Testing Materials specifications.

White and High-Alloy Cast Irons: Important changes in analysis or the use of sizable quantities of alloys will materially alter the characteristic properties of iron castings. They can be made very hard to resist wear or erosion, relatively stable at elevated temperatures to resist scal-

ing and creep, or chemically passive to resist some kinds of corrosive attack. High-alloy castings can be made nonmagnetic or with a very low coefficient of thermal expansion.

Nodular (Ductile) Cast Iron: This recently developed material is also known as Ductile Iron or spheroidal-graphite iron (S-G iron) and is considerably different from gray iron in its properties. A slight but specific modification in the anaylsis of the iron causes the graphite particles (which are flake-like in gray iron) to occur as spheroids in nodular iron. This gives the nodular iron a high

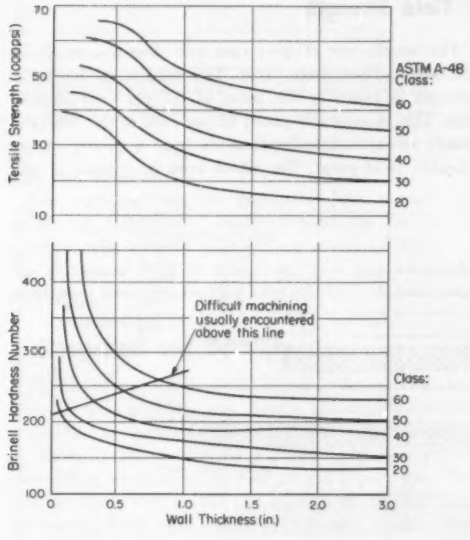
Properties of Cast Irons

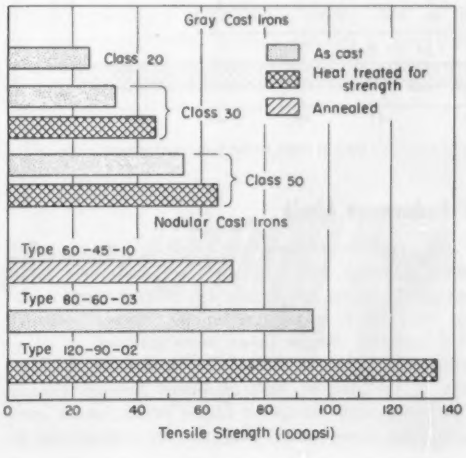
Tensile Strength

The most frequently specified property of cast iron is its ultimate tensile strength. While tensile strength is easily measured, it is important to select a test specimen which represents the properties of the metal in the casting. The properties of all metals are affected by their solidification and cooling rate; gray iron is particularly sensitive.

A light and a heavy casting made of the same metal will have a difference in their properties. Effect of the thickness of the casting on the strength and hardness of unalloyed gray iron is shown. The detailed explanation of this phenomenon is complex, but basically every casting is a heat-treated part by virtue of its cooling from the molten form. All heat treatments of irregularly shaped parts are complex processes and normally uneven in effect. Thus, the tensile strength of a given section of a casting is as much influenced by its casting history as by the metal used. Hence, it is a fallacy to specify structural types of cast iron solely by chemical composition. For production control, separately cast test bars are used in a size which is representative of the critical section of the casting.

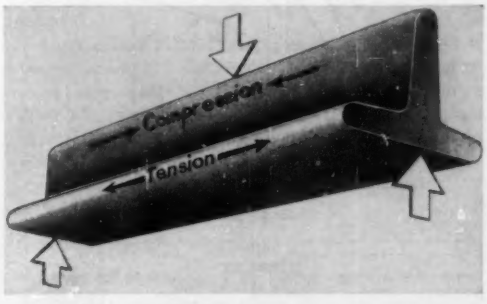
Typical production strengths of several cast irons for both the as-cast and the heat-treated condition are also shown. Most classes of iron can be significantly increased in strength by heat treatment at some sacrifice in other properties, but this treatment is not applicable to all castings because of size and shape limitations. For some design calculation, it is necessary to use a guaranteed minimum tensile strength. The ASTM class number equals the minimum tensile strength in thousands of psi. The shear strength of gray cast iron is approximately equal to its tensile strength.

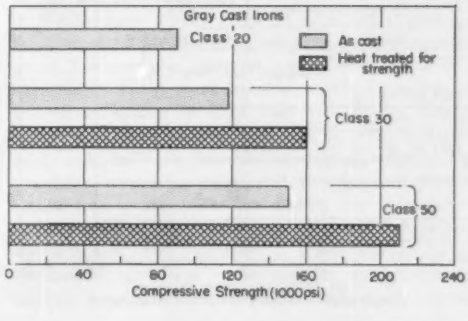




Compressive Strength

Cast irons have particularly good compressive strengths. For gray iron, compressive strength is generally three to five times the tensile





yield strength and ductility, but some of the other properties are also modified. There are several grades of nodular iron which are designated by code numbers based on their elongation, yield strength and tensile strength.

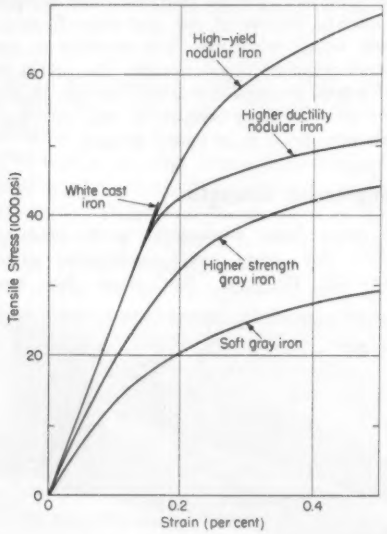
Properties: Characteristics of the various types of cast iron are outlined in the section on *Properties of Cast Irons*. Ordinarily, the mechanical designer is not concerned with properties other than those listed, but there are a number of applications for castings where special requirements are necessary, such as for performance at elevated temperatures. Specifications for this class of work include high-temperature oxidation resistance, short-time tensile strength, and creep rate. Occasionally, consideration must be given to the electrical or thermal conductivity, coefficient of thermal

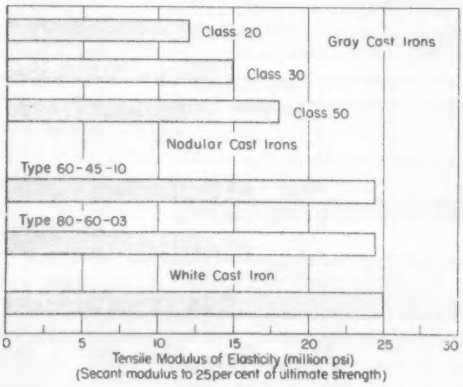
Properties of Cast Irons (continued)

strength. This has had an obvious influence on design, and is the basis of the old designer's rule: "Place ribs in compression." A relatively wide flange or web is often used to carry tensile stress; the conventional I-beam is often replaced with a T-beam in designing for gray iron. Where members are primarily in compression (for example: bases, die blocks, and saddles), gray iron is directly comparable with the higher strength steels.

Modulus of Elasticity

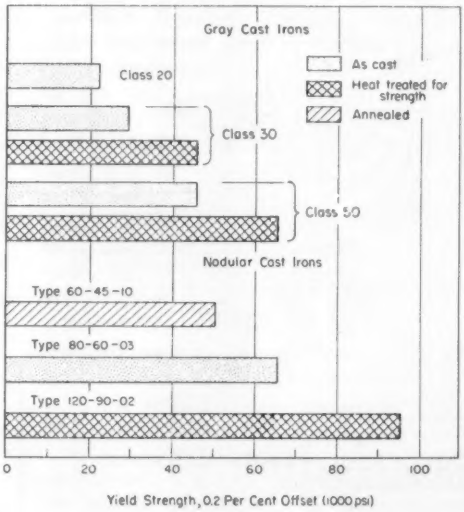
Nonductile types of cast iron theoretically do not have a modulus of elasticity, since no portion of the stress-strain curve is a straight line. However, there is only a minor variation in the slope of the stress-strain curve in the commonly used range of stresses. For engineering calculations of gray cast iron, it is common to use the slope of the load-deflection curve at 25 per cent of the tensile strength. By changing the composition or processing, it is possible to vary the modulus of gray iron. In applications requiring resistance to heat shock, a low modulus of elasticity is essential. Nodular and white cast iron have a modulus more closely approaching that of steel.





Yield Strength

The tensile test of gray cast iron does not result in a clearly defined yield point. The usual value for yield strength is taken at the point of 0.2 per cent elongation. This is generally about 85 per cent of the ultimate tensile strength. Ductile irons do have a clearly recognizeable yield point. The white irons have none at all.



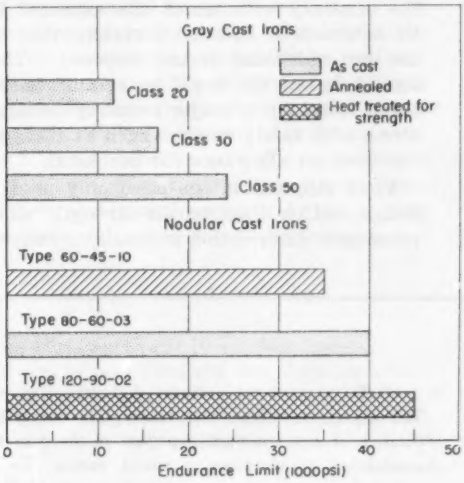
Endurance Limit

The endurance limit—the limiting stress below which a metal will withstand an indefinitely large number of cycles of completely reversed stress without fracture—is a measure of the fatigue potential of a material. Values shown were obtained on a rotating-beam machine where the stresses in the surface of the samples were alternated between tension and compression. Somewhat higher values can be used where the stress varies from zero to a maximum in

expansion, magnetic properties and specific gravity. Data on all of these are available.

Strength of a material is rarely the sole criterion for its selection. Usually, a balancing of different requirements is necessary, in which considerable judgment must be exercised. Gears are an example. In this case, wear characteristics, resistance to spalling and flaking, endurance limit, and vibration-damping qualities are decisive.

Strength and Deflection Calculations: The first step in the analysis of a casting application is to establish all of the relevant requirements. These should include environment conditions, loading, expected life, weight or size limitations, and a description of adjacent and mating parts. There may be applicable legal codes, such as the ASME, ICC



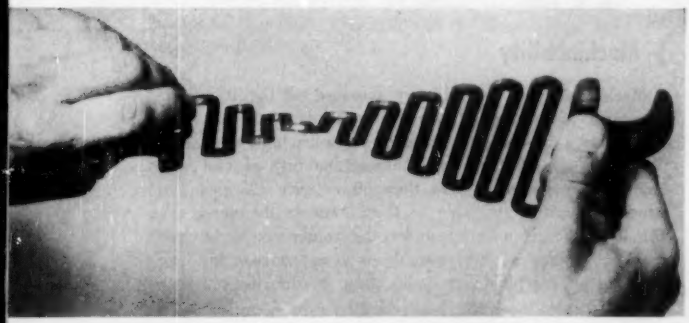
only one direction.

For gray cast iron, the endurance limit is about 35 to 50 per cent of the tensile strength. In contrast to other metals, notches have only a minor influence on the endurance limit of gray iron. This lack of notch-sensitivity is an outstanding characteristic of gray iron.

Elongation and Ductility

Plastic elongation is used as an index of the ductility of metals. While gray iron is not usually thought of as having ductility, elongation does range from 0.2 to about 1 per cent. The high-strength, heat-treated irons show elongations of less than 0.2 per cent. The nodular irons test in the range of 3 to 20 per cent, depending upon type. These values are results from tensile test specimens.

Under conditions of multiaxial stress, such as in the presence of notches or sharp changes in geometry, the ductility may be substantially reduced. Thus, the ductility of a material in a complex structure may be considerably different from that indicated by a conventional test piece.



Occasionally, designers are concerned about the lack of ductility in gray cast iron. However, gray iron does have measurable deflection. The part shown is a gray cast iron resistor grid used in electric motor controls. It has been warped so that the end connections have been displaced about 45 degrees. This is substantially elastic deformation, and the part will return to the original flat shape when released.

The significance of ductility in many cases of design has been exaggerated. The elongation figure usually measured in tests is the maximum reached in a tensile failure and is quite unrealistic. The elongation at the yield point (about 1 per cent for mild steel) is more significant.

In many cases, the usefulness of a member or structure is limited by the allowable deflection. Beyond this point, the part is just as useless as though there were a tensile failure.

On the other hand, it must be realized that gray iron's lack of ductility does not permit equalization of stresses under severe overloads. For example, when two ductile cast iron members are bolted together on faces considerably out of alignment, plastic deformation can take place until the faces are in complete contact. These members can then continue to serve effectively if the distortion is not detrimental. Under the same conditions of misalignment, gray cast iron might crack if conformance were forcefully attempted.

Another limitation of gray iron is its relatively low impact strength. The higher tensile strength gray irons have somewhat better impact properties than those of lower strength. The annealed nodular irons have good impact resistance, and should be used where this property is important.

Hardness

Range of hardnesses available in cast irons is similar to that available in steels. However, equivalence in the hardness of two different materials should not be interpreted as indicating equality in related properties. For example, gray cast iron of over 400 Brinell hardness is likely to be at least as wear resistant as a medium carbon steel of over 600 Brinell (Rockwell C60). The matrix of cast iron is actually harder than indicated because the testing instrument determines average hardness, and the graphite present in the iron is very soft. The Brinell test is preferred for determining the hardness of cast iron, as it covers sufficient area to give a good, average value. Hardness of gray iron varies with its tensile strength, but not in a simple direct relation as in steel, because

or API. Government specifications are increasingly important. The service conditions might involve steady or variable elevated temperatures, corrosion or wear. Special applications may require electrical or magnetic properties.

The next stage is to determine conditions of loading. These are the peak intensity and degree of impact, location and direction of forces, and whether they are steady, varying from zero to maximum, or alternating from a positive to negative maximum. Eccentric forces should be resolved into axial, bending and torsional components. Assembly forces and effects of normal or extreme handling should be considered. With this information, it is possible to analyze the forces and to lay a foundation for the design.

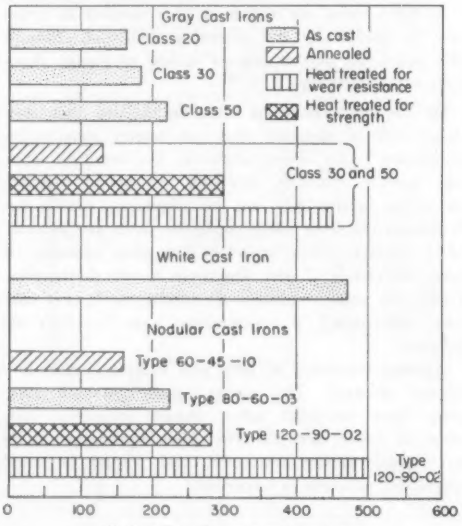
With complex or critical castings, the entire procedure will be required in considerable detail, but for the great majority of noncritical castings the analysis is informal or instinctive. The experienced designer, especially when working on a familiar product, will recognize low-stress castings by inspection. The procedure then is to "eyeball" the casting; tnat is, to draw them as seems necessary to fulfill a mental summation of the requirements.

It is now necessary to determine the allowable stresses and deflection. The selection of the factor of safety depends on the judgment of the designer. With the variety of applications in use, it is not surprising that there should be a range of values from 3 to 10, and even greater.

Many factors need to be considered in establishing a reasonable factor of safety. First, there is the accuracy with which the expected loads can be determined, and the certainty that there will not be additional forces imposed. Then there should be an additional margin if failure would result in injury or major property damage. Mechanisms with safety devices, such as shear pins, may not need an allowance for overloads.

Yield strength is the commonly used basis for design, rather than tensile strength, since major, permanent deformation is usually synonymous with

Properties of Cast Irons (continued)



several factors are involved. For example, the shape of the graphite can influence strength more than it does hardness.

Castability

Castability of a metal refers to the ease with which it can be cast into thin sections with complete detail, and the ability to be cast into complex sections without internal defects. Ease with which the liquid metal will continue to flow in a mold depends upon its analysis and the pouring temperature. Tendency of a metal to form an oxide layer on its molten surface may materially reduce castability. Molten cast iron is one of the most fluid of casting alloys, and it normally presents no problem of surface film.

The change in volume that takes place during solidification of metal is most important to the ease and dependability of obtaining a sound casting. To be sound and true to pattern, a casting must be fed additional liquid metal while it solidifies. This is necessary to make up for the decrease in volume of the metal in changing from a liquid to a solid. This "feed metal" is usually provided by an appendage called a "riser," which is attached to the casting. The riser is removed when the casting is cleaned.

Amount of solidification shrinkage differs considerably with various casting alloys. Gray cast iron has in general less shrinkage than other casting alloys, since the unique precipitation of lightweight graphite during solidification offsets part of the shrinkage that would otherwise be evident. In fact, Class 20 and 25 irons (ASTM Specification A-48) contain sufficient graphite so that there is often virtually no solidification shrinkage. However, solidification shrinkage should not be confused with the contraction provided for by the patternmaker's shrink rule. Contraction of the solid metal from the time it solidifies until it cools to room temperature is a matter of ordinary solid thermal contraction. This is regularly provided for by making the pattern a proper amount larger than the size desired in the casting.

Machinability

Machinability is an arbitrary measure of the relative ease of cutting a metal. One standard of comparison is a free-cutting grade of screw-machine steel. With this as 100 per cent, the machinability of cast irons will range from less than 50 to over 125 per cent. The critical variable in these tests is the need for testing each material under the conditions to be used in production. For example, it is not satisfactory to use the machinability index from a drilling test

failure. Where there are a large number of rapid cyclic load applications, the endurance limit is used. For precise design, a distinction should be made between fully reversed bending and zero to maximum loads, and between indefinite life and a relatively small number of stress cycles. For example, it is logical to assume that trucks will be operated at capacity load 50 per cent of the time, while passenger cars typically carry a full passenger load only a fraction of their total mileage. Impact loads are often too complicated to calculate, and are usually covered by a factor of safety of 1.5 for moderate impact, and 2 for severe impact.

The last element in the factor of safety is the possibility of encountering variability in castings. This variation may show up as minor reduction in the thickness of a critical section or a major reduction in the effective cross-section area due to casting defects. This variation will be at a minimum in foundries with close control over their operations. Where the typical strength in the casting is far enough above the required minimum and the variation in properties is sufficiently small, additional consideration for a casting is not necessary. However, in critical work, an extra factor of 2 is frequently added where it would not be for a wrought material. With a thorough inspection of each casting, this factor might be omitted. The use of X-ray or gamma rays is becoming increasingly popular to establish sound foundry practice, and also for inspection in critical work.

Allowable deflections are determined from a study of the function. In hydraulic machinery, deflection often results in an increase in leakage; upper limit of leakage may be specified. Where there are relationships among cams, linkages, or latches, deflections are specified in terms of error of positioning. The alignment of sliding members is determined by the maximum wedging or cocking action permissible.

Evaluating Casting Design: In the development

as a measure of the cutting rate on a milling operation.

Although irons of higher strengths and higher hardnesses are generally less machinable, it is important to recognize that there is no consistent relationship between hardness and machinability.

Wear Resistance

Cast iron serves effectively in the two principal classifications of wear. These are: (1) metal-to-metal or frictional wear, and (2) abrasive wear, which is caused by the grinding action of a hard material. Gray iron is used extensively for engines and other machines with rubbing faces. The good wear resistance of gray iron is often attributed to the presence of graphite flakes scattered through the iron, much the same as in graphite-impregnated bearings. Of course, there should be lubrication for best operation, but gray iron can be used with marginal lubrication where other materials would fail.

The type of wear caused by abrasive materials is usually handled with the harder grades of cast iron, some of which are still machinable. Hardened gray iron and white cast iron are especially suited to high unit pressures where indentation must be avoided. There is no exact correlation between hardness and wear resistance, since several other factors are also important. Although considerable information is available, the only conclusive test of suitability is the actual use of the part in the service for which it is intended. Previous experience is the best guide to preliminary selection.

Corrosion Resistance

Although not generally classified as a corrosion-resistant material, unalloyed gray iron normally offers better resistance to corrosion than other general-purpose ferrous materials. Under atmospheric conditions, ordinary cast iron rusts quite readily. However, this rust forms a relatively adherent protective coating, which offers fairly good resistance to atmospheric and soil corrosion, to some acids, and to alkalis. Some cast-iron water mains and gas lines have served for more than 100 years. Special alloy cast irons are used for some of the more difficult corrosion problems.

Vibration Damping

Gray cast iron has outstanding damping qualities. An important reason for its use in machine tool frames is its ability to absorb vibration. This is especially important with interrupted cuts, as on a milling machine. Without this property, the machine could develop resonant vibrations which would result in noticeable chatter marks and noise. Gear trains running in cast iron housings are generally quieter than they would be in steel housings.

Relative damping capacities of several materials are shown. It is significant that damping capacity is an inverse function of the modulus of elasticity. This range of properties is used as a factor in the design of crankshafts where severe torsional vibrations can be avoided by selection of the optimum modulus.

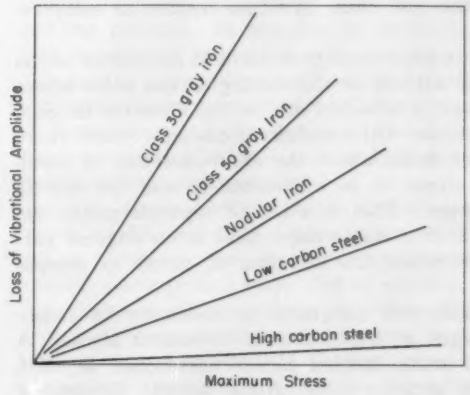


Fig. 3—Simple application of a wire strain gage to a saw table to check on grinding stresses.

of a new machine, the objective is to get components which will perform successfully when assembled and operated in the normal manner. This implies long-term tests of a number of units—a slow, expensive process. A number of direct methods can be applied to shorten the development period.

With a sound, typical experimental casting, structural types can be evaluated by load-deflection tests. External loads are applied to correspond to normal or abnormal forces. Strain gages of the SR-4 type are located in the critical locations and directions. A simple test employing only one gage is shown in Fig. 3. These small, inexpensive gages consist of a length of very fine wire arranged in various patterns, and bonded to a paper base. In use, the gage is cemented to the member to be tested and is thus uniformly strained with the test piece, in either tension or compression.

Strain gage tests give the unit elongation in the outside surface of the casting at the point where the gage is attached and in the direction of gage orientation. On complicated castings, where there may be doubt about the exact direction of maximum stress, it is convenient to use the rosette type gage. This is a set of separate gages, cemented on a single paper base in an angular pattern to reveal the direction of stress by components.

Considerable judgment is necessary to locate the gages at the points of maximum stress. A special brittle lacquer called "Stresscoat" is often used to indicate these critical points. Crazing of the lacquer when the casting is loaded shows high stress areas in the form of concentrations of cracks in the lacquer coating. Actual strain measurement is possible by determining the threshold strain value necessary to to produce cracks on a standard specimen, but controlled conditions and considerable experience are necessary to obtain dependable data in this manner.

Values for stress are determined from strain measurements by use of the modulus of elasticity. For approximate work, the modulus can be estimated by measuring the tensile strength. For critical work, however, the actual modulus curve should be obtained by determining the stress-strain curve on a specimen representative of the iron in the casting.

Accelerated life tests to reveal wear, corrosion or fatigue characteristics must be conducted with care if the results are to be an accurate evaluation. The acceleration of the test must not change important conditions of service.

In addition to these direct considerations of a casting's suitability, other interested departments should also check the sample castings. Manufacturing should make final decisions on machining rates and study the actual use of jigs and fixtures. Finishing and assembly departments should have a final chance to spot potential problems in their operations. The service department often can advise on problems that may develop when the product reaches the customer.

Designing for Appearance

Inherent Design: One of the objectives of industrial design is to produce a part with pleasing lines. The ideal is often somewhere between widely flowing curves which completely envelop the part, and sharply angular, flat-faced designs. Fortunately, one of the advantages of the casting process is that, by its very nature, it allows an approach to design which yields a pleasing appearance. Generally, a part which is castable has a better than average chance of being considered attractive. In fact, the flexibility of casting design permits the use of compound curves which would be difficult to obtain with other fabricating methods. Fig. 4 shows a gear drive with a wide, flowing base which suggests ruggedness and stability.

A large amount of the current industrial design work is on housings for machinery. There has been a tendency to neglect the appearance of the interior mechanism, since it is to be covered up in service. Granted that housings are often necessary to keep monkey wrenches and peoples' hands out of the works, there is still no reason for always hiding attractive machinery.

Actually, machinery should be accessible for maintenance. In recent years there has been a reaction against the "streamline era" during which hydraulic and electrical components of machine tools were buried inside of the main housing. These exposed auxiliaries now often need the same de-

sign effort for appearance as the main housings.

Much machinery has been built recently in which the mechanisms are mounted on a frame, which is then enclosed. One of the real advantages of castings is that the inner structural member can be combined with the outer sheath. The structural stiffness is supplied by ribs, and the mounting points for mechanisms are the bosses and integral brackets. This construction, which is rather similar to that of clock motors, enforces an especially close relationship between function and appearance.

Applied Design: There is a limited field for surface markings used with discretion. While the abuses of the 1890 period should be avoided, there need not be any large blank faces.

With skillful minor shading, it is possible to emphasize the length of a part, or its height, solidity, or slenderness. Dividing up a large area with bands or panels helps to minimize rejections due to minor surface defects. Surface markings can be used to reduce the prominence of a row of exposed screws by incorporating them in a slightly raised band. Also, an unbalanced appearance of a machine's components can sometimes be made more acceptable by balancing with raised panels.

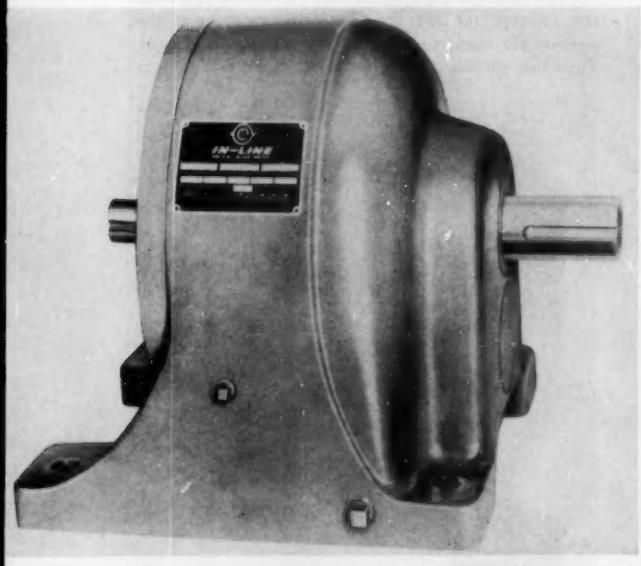


Fig. 4—Cast gear-drive base, with clean, flowing lines suggesting ruggedness and stability.

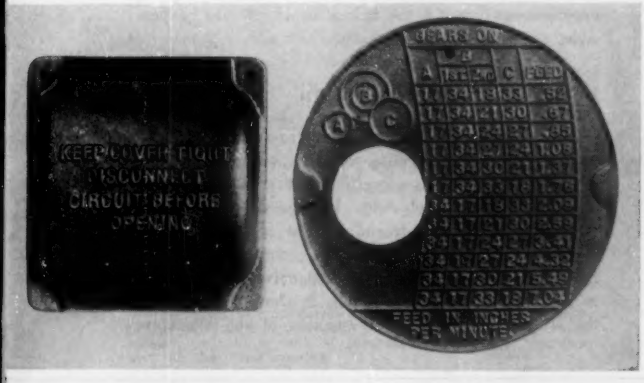
Trademarks are easily incorporated in the applied design. This can be done either as simple lettering and insignias or as a complex pattern. Where a sufficiently fine finish is available, sharply defined characters as small as ¼-in. are practical.

Instructions and nameplates are often cast integrally, Fig. 5, eliminating the possibilty of mismarking or loss through painting over. For maximum legibility, the lettering is sometimes painted in a contrasting color. After a general base coat, a layer of paint is rolled on the tops of the letters. Occasionally, the tops of the letters are lightly belt-sanded before rolling on the contrasting color to increase legibility.

Techniques in Styling: It is much easier to understand the arrangement and functioning of a casting from mechanical drawings than it is to visualize the appearance. Three-dimensional illustrations such as isometric and perspective drawings will help, but still require interpretation. The best study of appearance is with a scale model, full size when possible.

This model might be a wood, clay or plaster mock-up for a study of appearance. Or it might be an accurate working model for a study of functioning and relationships with adjacent equipment. In either case, nontechnical personnel can get a clearer understanding of new developments, and consumer reactions can be polled more exactly with a model than a drawing.

Fig. 5—Below—Integrally cast instructions and operating data. Information in this form remains legible and is permanent.



Designing for Producibility

A model will help to decide the question of castability on complicated parts and the details of molding practice. It will also be useful in planning machining operations and assembly.

A casting designed so that it will satisfy strength and performance requirements still must be capable of manufacture. Even at this advanced stage in development, the design is only preliminary and its producibility must be studied.

In the stress analysis stage, casting design is not much different from designing for other fabricating methods. But designing sound and economical castings is a more elusive matter.

A designer who is overly impressed with the need to provide uncomplicated designs to simplify molding may lose sight of chances to make major product improvements. A more expensive casting can be welcomed if there is a compensating

reduction in the cost of other stages of manufacture.

To take full advantage of the casting process, the designer should not avoid complexity but should incorporate it, up to the economical limit. The objective should not be the simplest casting, but should be the most economical one, with all facts considered. This economic limit will vary for different applications and often can be determined by comparing cost studies of alternative designs.

Of course, the designer should have a working knowledge of the factors that affect producibility. There are no rigid rules which apply consistently, although there are some general principles.

Soundness of Castings: Obtaining castings which are free from flaws is a continuing problem for the foundry, but most grades of cast iron are fairly good in this respect. The high fluidity of the molten metal and the low shrinkage during solidification permit successful castings to be made of some shapes impossible with other metals.

The general comments in the section on *How To Design Sound Castings* are primarily intended as

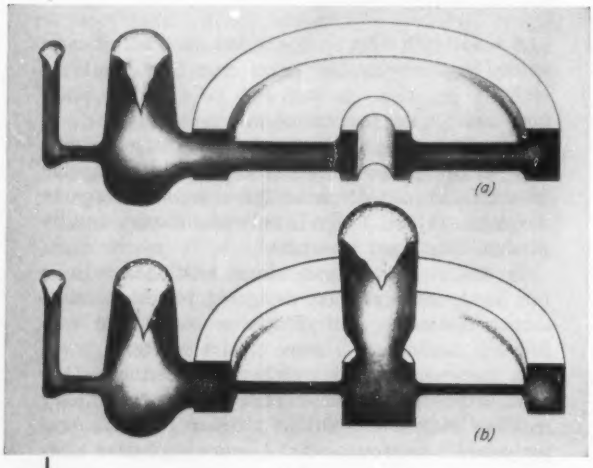
How to Design Sound Castings

Plan Sequence of Solidification

Sequence of solidification in a casting affects the soundness of the casting. This is primarily dictated by the shape of the part, but the foundry usually can help with changes in molding and casting techniques.

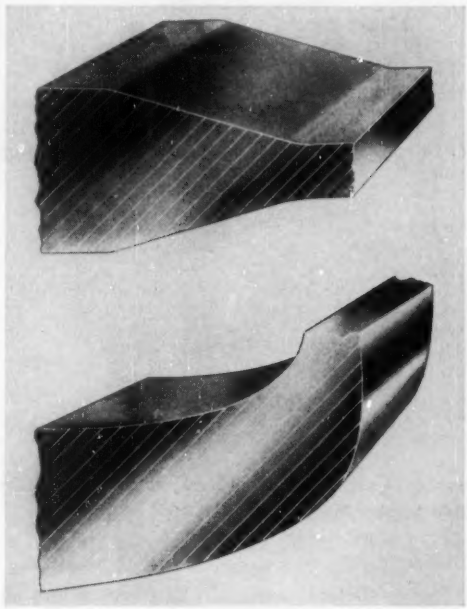
An example of a good sequence of solidification or directional solidification is shown. The sheave casting, *a*, has a sufficiently light hub that the molten metal solidifies first in the hub after the casting is poured. The disk portion solidifies second and the rim is the last part of the casting to solidify. The riser (shrink bob) is attached to the last part of the casting to solidify, and since all solidification was progressive to this point, the casting will be completely sound. (Solidification proceeds around the rim from the side farthest from the riser because the molten metal is cooled somewhat in flowing that far in the mold.)

The casting in *b* has a heavy hub and rim separated by a thin disk that solidifies first. The foundryman must provide an additional riser to feed the hub, or else it will not be sound unless the casting is poured in a grade of iron which has no appreciable solidification shrinkage. Isolated heavy sections which are not readily accessible for risering may be cast satisfactorily by the use of mold inserts (chills). While the foundry can use a number of special techniques, dependence on these may delay production and can increase the cost of the casting.



Connect Sections with Generous Tapers

While adjacent sections of widely varying thickness can be cast, the foundry's job will be easier if the sections are connected with generous tapers, as shown. Thickness variations in ratios up to 4 to 1 (i.e., 1 to



¼-in.) are generally no problem. Differences greater than this can often be handled, particularly if property requirements are not too severe or if alloying is possible.

Choose Proper Fillet Radii

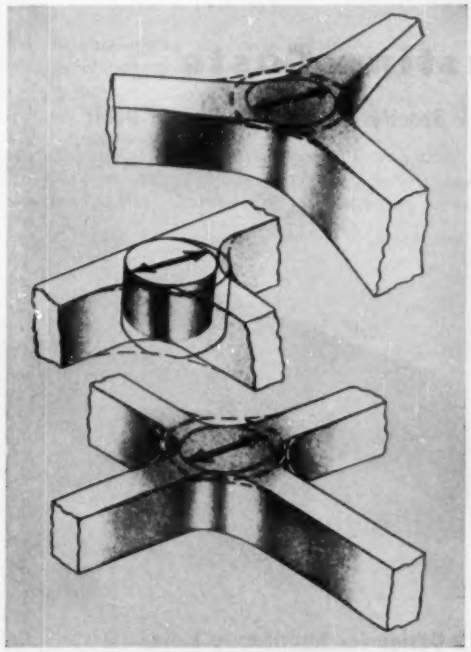
A good fillet radius should be approximately equal to one-half the average section thickness, with a minimum of ¼-in. Here there is a conflict of interest which must be resolved in special cases. Large radii favor lower stress concentrations, streamline flow of molten metal in the mold, and easier pattern withdrawal. Smaller fillets, however, avoid isolated concentrations of metal in a Y, T, or X-shaped section, as shown. Severity of the shrinkage problem is a function of the diameters

a guide for the less experienced designer. The man who has seen many castings go into machinery realizes that there are times when these precautions can be waived. On the other hand, there will be some castings which will be especially difficult to cast. Certainly, the foundries with experienced, scientific management and process control can be expected to produce good castings of a design which might cause a high scrap rate in a foundry without these attributes.

Factors Affecting Casting Costs: It is possible to approach the subject of cost reduction by studying the elements of casting costs. This is a joint responsibility of the designer and foundryman. The section on *Controlling Casting Costs* points out some of the methods of minimizing the high-cost features of a design.

Certain cost elements can be labeled "direct" costs; others, not pertaining directly to the casting as supplied are "indirect" costs.

Direct costs are all replaced by a single cost



of the inscribed circles. This consideration is of less importance when casting in gray iron than in other

Avoid Projections Opposite Critical Faces

Care must be taken where an exposed, critical face is backed up by ribs and bosses. If these interior projections are very large compared to the face thickness, there may be a hollow on the face opposite the projections. Where the face is to be machined, a slight padding on the face side will avoid the dimple. When appearance is the only consideration, a decorative pattern on the face will minimize the apparent defect.

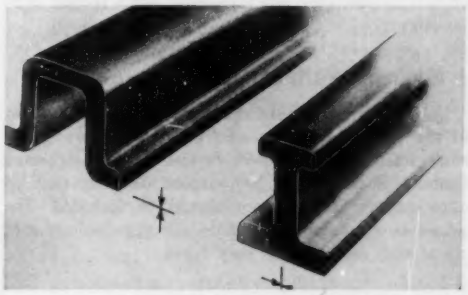
Support Cores Sufficiently

Core shifting should be guarded against by the use of ample support. Where a casting with a blind cavity is required, an extra core print* sometimes can be used to advantage, even though it results in an unnecessary opening. Chaplets* should be used with caution, since it is sometimes difficult to obtain effective fusion.

*Core print—an extension of the pattern or of the mold cavity for locating the core. Chaplet—a metallic insert or support to hold a core in position in the mold; becomes part of the final casting.

Avoid Cores Where Possible

Cores in beam-shaped members can sometimes be avoided by replacing tubular sections with U or I-type open sections, as shown. This helps provide better castings by eliminating the cores. On the other hand, a core is sometimes used in a large hub where a hole is to be machined. This is done, even though it would be no more expensive to drill out a solid hub if use of the core decreases the casting thickness ratio. However, a core that is thinner than the metal section around it may also be a problem.



Compensate for Differential Cooling

Complicated castings with concentric structures sometimes are troubled by cracks caused by the differential cooling of the various sections of the casting. Good design can help offset this condition. For example, a handwheel rim can be offset from the hub to allow for the relieving of cooling stresses. A small, uneven number of spokes or curved spokes would help. However, the millions of straight-spoked wheels which have been successfully cast are evidence that this is not commonly a problem.

when the castings are obtained from an outside supplier, or if a comprehensive cost-control system is in use in a captive foundry. It is possible to compare direct costs on two alternative designs by getting quotations on each. However, the indirect costs should also be considered for a complete analysis.

It is possible to go beyond these cost considerations to attempt a comparison between a casting and a part made by an alternative process. However, this is an exceedingly difficult job, since all of the direct and indirect costs in both processes must be considered, and the two parts must be comparable in all respects. Even with these requirements satisfied, no general conclusions between processes can be drawn because changes in time, location and company will affect the balance.

Detail Design: Money can also be saved in the details of a design. Aids for machining, elimination of coring, and reduction of processing time are all possible. These methods are outlined in the section on *Design Tips*.

Casting Tolerances: It barely needs to be stated that there are direct benefits from close casting

Controlling Casting Costs

Design for Rugged, Simple Coring

Number of cores, their size and complexity are important cost factors. Also to be included are core preassembly, gaging, installation in the mold, and chaplets (when used). Changes in design that permit green sand cores are worthwhile, as is the consolidation of cores. Cores rugged enough to be made without internal wires or rods are less expensive than those which require reinforcement.

Minimize Pattern Costs

Unit pattern costs are determined by the total cost of the patterns, match plates, core boxes, core driers, and special flasks if used, divided by the estimated quantity of castings to be produced. On long runs an allowance for maintenance should be included. The principal cost reduction possible is in the elimination of cores, and, consequently, core boxes.

Determine Economical Quantities

The quantity involved is a factor in costs, in that it determines the type of pattern and molding equipment used. The daily or monthly rate may be more significant than the total quantity. This determination of economic lot size has been studied and used by experts in many fields. The principles also apply to castings.

Reduce Cleaning and Grinding Time

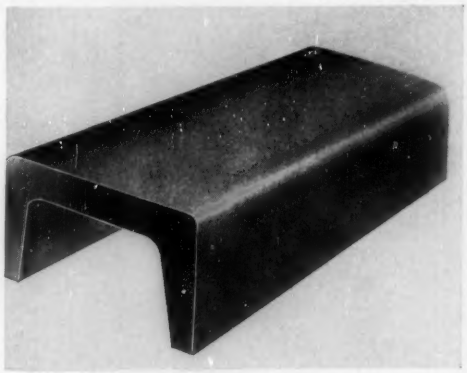
Cost of cleaning castings is a surprisingly high percentage of the total cost. Castings with small gates and risers require a minimum of hand grinding. If gates and risers are located on unimportant faces, they may not require any work. A plane parting line is most easily cleaned. Cores positioned by several generous core prints, not only are more easily and accurately located, but can be cleaned out more economically and thoroughly. Castings rugged enough to be tumbled can be cleaned with less handling.

Select a Castable Metal

Type of metal used affects castings costs directly. An increase in the percentage of rejected castings may result from the selection of a material not having the best castability.

Specify Generous Radii and Draft

Minimum radii and draft allowances in internal green sand pockets may cause molding difficulties. An exaggerated example of recommended practice is shown.



Design for Multicavity Molds

Molding time for uncored castings is about the same, regardless of design complexities, for a given flask size when using mounted patterns and mechanical molding equipment. Thus, multicavity molds are a clear advantage, and there is no cost penalty for the addition of extra elements or detail.

Plan for Subsequent Machining

Cost of machining is frequently the major item in manufacturing. Machinability rating of the iron, volume of material to be removed, and use of locating fixtures are all involved in casting design. Poor casting design may be responsible for defects which are not discovered until part of the machining has been completed. Cost of this wasted machining should be considered a charge against this particular casting design in the cost analysis. The foundry's liability is limited to the replacement of defective castings.

Consider Gaging Methods

Assembly operations are simplified with accurately gaged castings which fit mating parts. Typical gages

tolerances. For small and medium-sized castings, there is the possibility of assembling unmachined castings. In general, the amount of metal to be machined is affected by casting tolerances.

For ordinary green sand molds, the closest tolerances can be held between points in one part of a flask, the greater error being across the parting line. The following list suggests the basis for the usual tolerance build-up.

1. Pattern deviation from the drawing. This is usually ±1/32-in. per ft.
2. Localized casting shrinkage deviation from the shrink allowance. This results from a minor error in judgment by the pattern maker in estimating the actual shrinkage resulting from the casting shape and molding conditions.
3. Warpage can be considered as the result of the restrained cooling of the casting. It results from the inability to predict accurately, in complex cases, which portion of a casting will solidify and cool first.

These three size factors are correctable by reworking the pattern, or by modifying the molding practice. For quantity production, this trial and error approach is entirely practical and these errors can be eliminated. However, the following production variables remain inherent in the casting process:

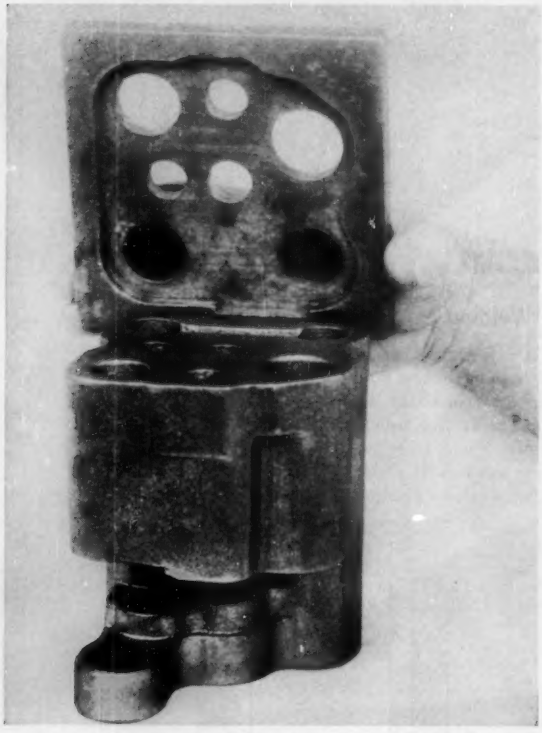
4. Molding variables may include pattern rap, core shift, sand pressure, mold growth, and shake-out time. Machine molding minimizes most of these variables.
5. Metal differences are usually in shrinkage, pouring temperature, and rate of pouring.

Naturally, when extremely close limits are required, there has to be a correspondingly good surface finish. Since there is no standard specification for surface finish, this must be agreed on by the designer and foundryman. Draft and gate projections also should be considered. The actual tolerances that can be supplied will vary in different foundries, and according to the class of work, but Table 1 gives typical figures for sand castings.

Closer tolerances can be obtained with rigid molds. Shell molds, with the sand bonded by a phenolic-type resin, can yield tolerances of as low as ±0.005-in. per in. Tolerances on ceramic molds resulting from the lost-wax or frozen-mercury processes are usually quoted as ±0.005-in. per in., but are often closer than this. Permanent-mold casting will yield similar tolerances though on simpler shapes.

It is interesting to note that the probe-type of surface roughness indicator is not applicable to cast-iron surfaces. For example, a honed cylinder made from bar stock might show about 4 microinches rms. When made of cast iron and given a comparable surfacing treatment, the indicator might show several times this value. Experience has shown that these seemingly rougher faces perform as well or better than those made from rolled metals. The explanation seems to be that the metallic portion of the cast-iron face is just

for checking casting dimensions are shown. A reduced number of parts will usually reduce assembly costs.



Reduce Size and Weight

Lighter, more compact and more rugged castings result in lower transportation and packing costs from the foundry to the manufacturer and throughout the distribution system.

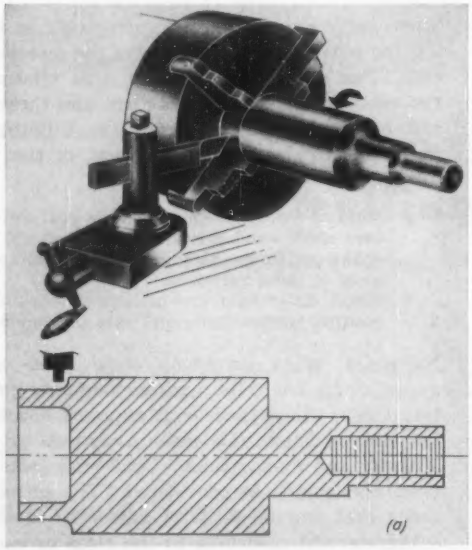
Table 1—Typical Sand Casting Tolerances

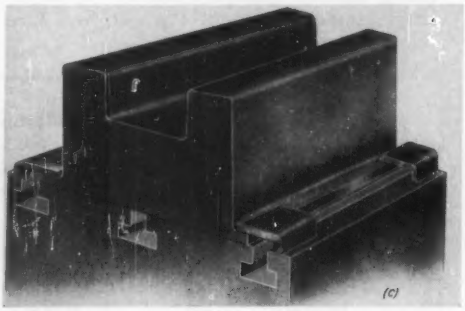
Approximate Size of Casting (in.)	As-Cast Tolerance (in.)	Additional Machining Allowance per Face (in.)
Up to 8	±1/16	1/8
8 to 18	±1/8	3/16
18 to 30	±3/16	1/4
Above 30	±1/4	5/16 to 1/2

Design Tips

Projections or Pads for Machining

Projections can be added to castings to facilitate clamping for machining. Where parts are to be machined all over, a chucking grip can be provided, *a*, which is cut off as the final operation.



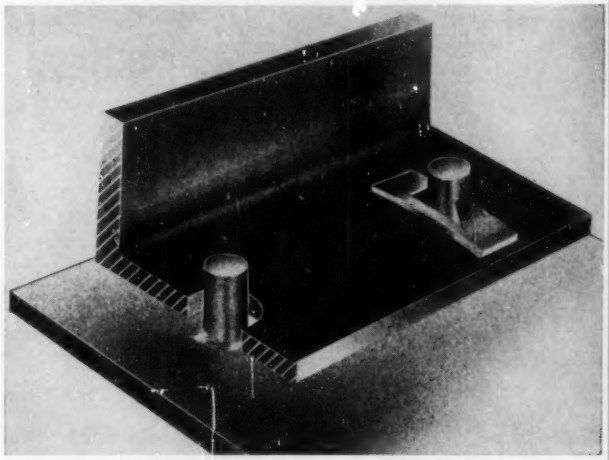


Awkwardly shaped parts can be handled in standard chucks with the addition of clamping pads, *b*. These pads may be inconspicuous and left in place or cut off when necessary. Where machining fixtures are provided, the pads serve as locating points. Some foundries can supply targeted castings in which these locating pads are accurately ground with respect to the body of the casting.

Clamping large, straight-sided castings to a machine tool table is simplified if projecting lugs are provided for the purpose. Small clamps can be used, *c*, and the entire face left clear for machining.

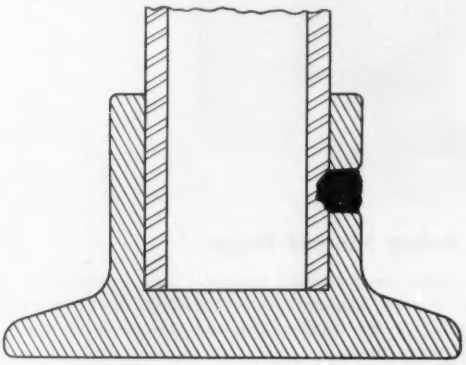
Mechanical Fasteners

Fastenings can be incorporated in design by using as-cast bosses, with push-on-type spring clips. Riveting is applicable to cast iron assemblies by using tubular rivets and rolling the lip down without impact.



Welding

It is sometimes necessary to secure a cast-iron flange or bushing to a steel tube or bar. A reliable anchor can be obtained by coring a side hole in the casting and arc welding a button in this hole on assembly, as shown. There is no need for fusion with the casting, since the lock is purely mechanical. Actual brazing or welding is also practical.



as smooth as the continuous face of rolled material, but that the stylus enters the pockets left by the exposed graphite flakes. Thus, the stylus tip has a greater amplitude, which the meter shows as a rougher face.

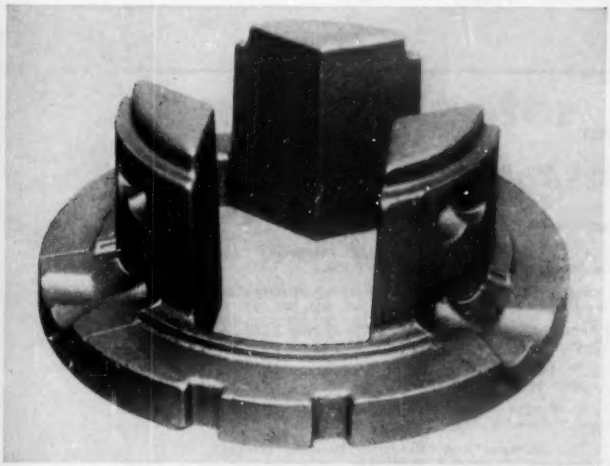
Inspection of Castings: After the casting design and foundry techniques have been established, it is necessary to insure that the production castings are comparable to the experimental model. It may be necessary to have 100 per cent inspection on difficult castings or those of critical importance. Usually, however, an occasional check is all that is necessary to determine casting soundness.

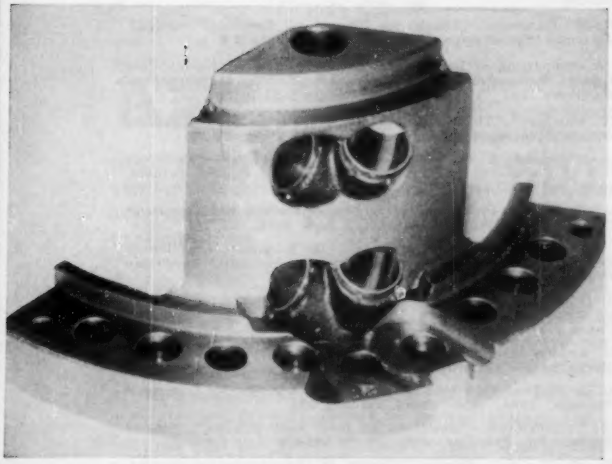
Among the destructive tests are fractures with a hammer blow, band-saw cuts in the critical locations, and loading to failure. The latter will show metal strength as well as casting soundness.

Nondestructive tests have come into use because of the need for 100 per cent inspection, and

Grouping Similar Parts

Some parts can be handled better in production as a set rather than singly. In one case. three parts were cast as one, with considerable advantage in handling and machining. They were turned, milled, and bored before being cut apart.



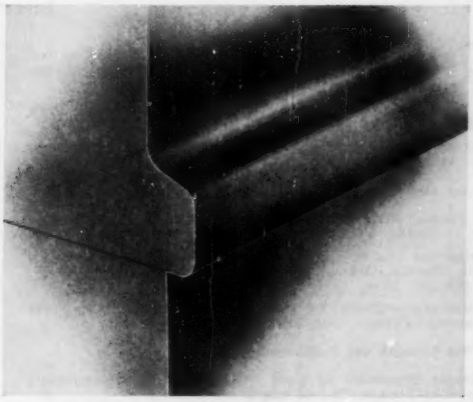


Eliminating Coring

Some intricate coring can be eliminated if a casting is made in two halves with a brazed or bolted connection of the halves. This is especially desirable if the core prints are so small that support would be inadequate, and clean-out difficult. Automotive automatic transmissions use control-circuit blocks of this type.

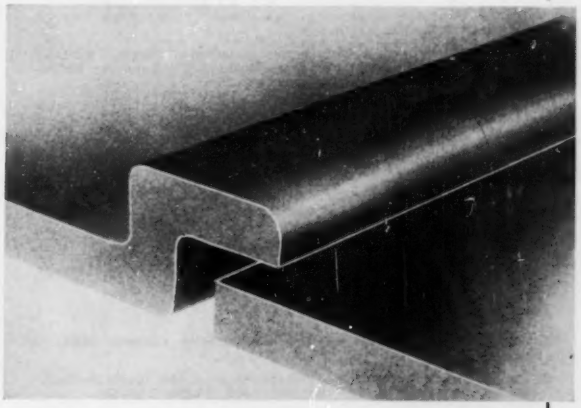
Registering Mating Castings

The problem of registering mating castings can be simplified by providing a bead on the edge of one of them. The customary range of casting tolerances can be accommodated this way, in addition to providing a decorative belt.



Joining Castings Without Machining

Where two castings are to be joined without any machining of the butting faces, the irregularities can be covered with a stepped joint.



are now widely used. X-ray tubes are used to produce radiation to penetrate castings. Any voids show as dark areas on the film behind the casting, because of reduced resistance to the passage of the rays in these areas. The use of gamma-rays from radioactive isotopes, such as cobalt-60, is even more flexible because of the small source of radiation. A cast cylinder can be checked by inserting the radiation source through a small hole and wrapping an X-ray film covered with sheet lead around the outside.

The Magnaflux method will show surface and near-the-surface cracks or voids by the pattern of a powered iron deposit. Ultrasonic flaw detectors, though not too effective for their primary use on cast iron, are used to determine the modulus of elasticity accurately. A number of dye penetrant methods make visible surface cracks which are so small that they might otherwise pass unnoticed. In all of these tests, considerable judgment is necessary to interpret the indications.

These newer test methods merely supplement the usual methods. An experienced inspector, working carefully in a well-lit area, can detect many defects. With a hammer blow, he can detect bad cases of porosity; with gages, warpage and critical dimensions can be checked. Over or underweight castings point to casting faults. Hardness readings, for a given material and section, will relate to tensile strength at that point. Special requirements, such as pressure tightness and electrical resistivity, are also checked.

The ASTM test bars play an important part by providing a standardized production control for the metal. Once the casting techniques are established, it is no longer so important to measure the actual properties in the casting itself, and the separately cast test bars are convenient.

After inspection, care should be taken to insure good handling of the castings. Careful packing, loading, shipping, and unloading are important, even with "rough" castings.

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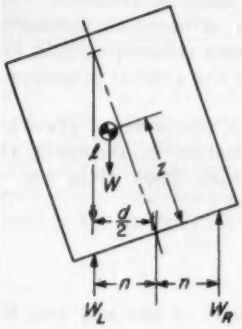


Fig. 1 — Above — Basic dimensional and load relationships for location of center of gravity in machine structures.

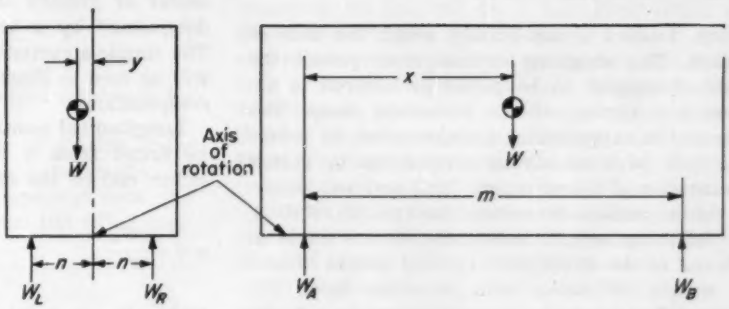


Fig. 2—Below—Analysis of weight difference measurements for railroad car. Difference between left and right side load-cell readings are plotted against plumb bob displacements for different tilted car positions, thus producing a hysteresis loop which eliminates errors introduced by frictional resistance to car rotation.

Locating Center of Gravity

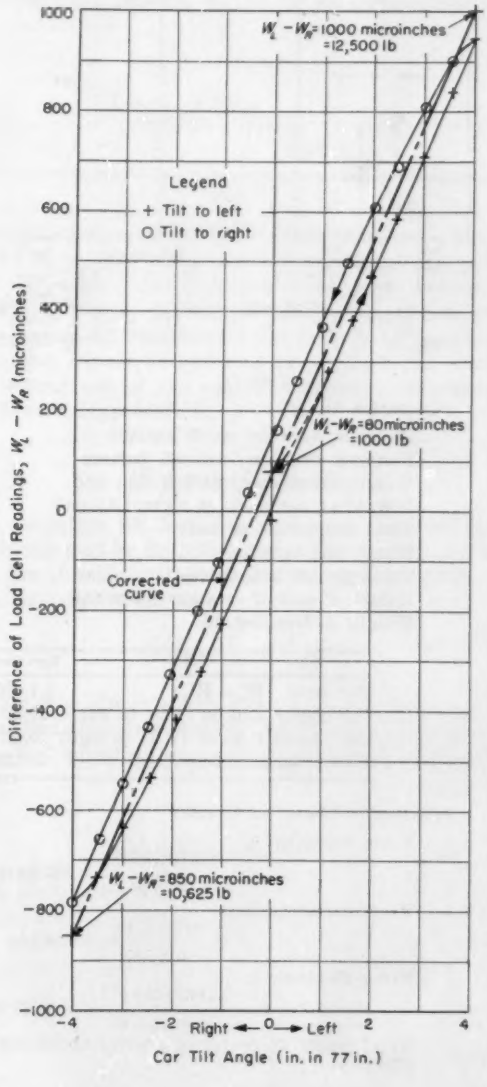
. . . in heavy or complex machine structures and assemblies

By W. E. Burdick
Engineer of Tests
General Steel Castings Corp.
Granite City, Ill.

ACCURATE measurement of center of gravity of machine structures is often necessary to verify design calculations. However, when structures become heavy or complex, conventional techniques for this purpose do not always yield satisfactory results or may be impractical in application.

A recently developed method of locating the center of gravity of a massive and complicated structure by means of a weighing technique has simplified the problem of checking extensive computations for railroad passenger cars. Variations of the method are applicable to other heavy or complicated structures when computations are laborious and subject to possible errors which should be checked by actual measurements.

Weighing Technique: In the application of this method, a three-point support arrangement is utilized to obtain weight measurements of the structure in level and tipped positions. One end of the structure is supported at two points by weighing



devices, located symmetrically about the axis of rotation. The weighing devices must permit the points of support to be raised or lowered to accommodate tipping of the structural mass. The other end is supported at a single point, by means of a ball joint or similar suspension to permit free rotation of the structure. Ball seat and weighing device centers determine the axis of rotation. The following weight measurements are made at each end of the structure: (1) total weight of end, (2) weight difference with structure level, (3) weight difference with structure tipped to left and (4) weight difference with structure tipped, at equal angle, to right.

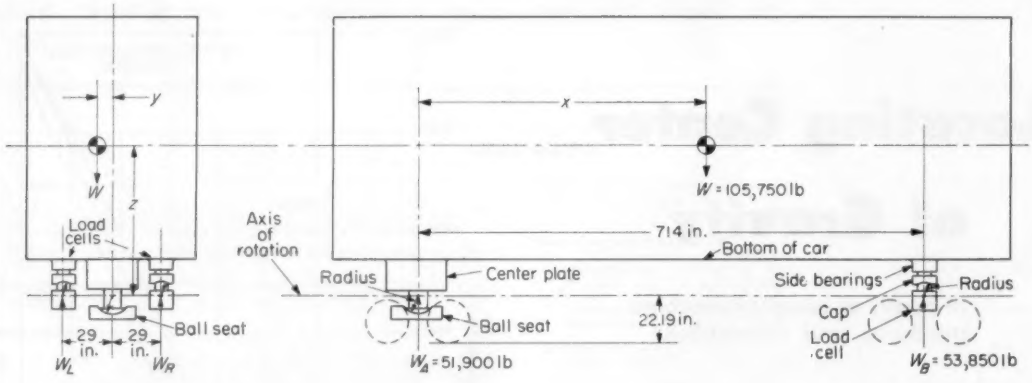
Evaluation of Data: From the data obtained in the various weight measurements, location of the center of gravity of a machine structure can be determined by a series of moment summations. The simple structure shown schematically in Fig. 1 will be used to illustrate the general procedure for computations.

Longitudinal position of the center of gravity can be found from a summation of moments about either end of the structure. Thus, from Fig. 1,

$$x = \frac{m W_B}{W} \qquad (1)$$

where W_B = total weight of one end and $W = W_A + W_B$ = total weight of structure.

Transverse position of the center of gravity, measured from the vertical centerline of the structure, can be found similarly by a moment sum-



Calculation Data

Distance between truck centers ..... $m = 714$ in.
Distance between load-cell centers ..... $2n = 58$ in.
Weight of car body at left (A) end ..... $W_A = 51{,}900$ lb
Weight of car body at right (B) end ..... $W_B = 53{,}850$ lb
Total weight of car body ..... $W = 105{,}750$ lb
Plumb line length ..... $l = 77$ in.
Total plumb bob travel ..... $d = 8$ in.
Height of axis of rotation above rail ..... 22.19 in.
Weight differences, lb:

	Left End (A)	Right End (B)	Average
Car level ($W_L - W_R$)	1,000	625	812.5
Car tipped 4 in. in 77 in. to left..	12,500	12,125	....
Car tipped 4 in. in 77 in. to right	10,625	10,875	....
Total load transference, T	23,125	23,000	23,062

Location of Center of Gravity

From Equation 1,

$$x = \frac{714(53{,}850)}{105{,}750} = 363.58 \text{ in.}$$

From Equation 2,

$$y = \frac{812.5(29)}{105{,}750} = 0.222 \text{ in.}$$

From Equation 3,

$$z = \frac{23{,}062(29)(77)}{105{,}750(8)} = 60.87 \text{ in.}$$

Total height of center of gravity above rail is: 60.87 + 22.19 = 83.06 in.

Fig. 3—Sample computations for location of center of gravity in a gallery car built for Southern Pacific Lines. Weight difference values are based on curve plots of the type shown in Fig. 2, which, in this case, represents the actual results obtained for the left or A end of the gallery car. Mid-axis of the hysteresis loop gives the true value of the load shift as the car is rolled, as well as the load differences when the car is tipped the maximum amounts. General mounting arrangement for weight measurements is shown in the sketch.

mation about the centerline:

$$y = \frac{W_L n - W_R n}{W} = \frac{(W_L - W_R)n}{W} \qquad (2)$$

where $W_L - W_R$ = average weight difference for both ends with structure level.

Vertical location of the center of gravity above the axis of rotation is given by a summation of moments about the center of gravity with the structure in the extreme right and left tilted positions:

$$z = \frac{Tnl}{Wd} \qquad (3)$$

where T is the average total load transference, or average of the sums of weight differences in the extreme tilted positions (right and left) at both ends of the structure.

Application Example: Principles of the method are illustrated by its application in a typical railroad car analysis. In this application, the car was supported on one end by a ball joint which engaged the kingpin opening for the wheel truck, and on the other end by two Baldwin SR-4 load cells of 50,000 lb capacity each, mounted on hydraulic jacks at the side bearings or jacking pads. Tipping forces were applied through the hydraulic jacks. Tipping angles were measured by displacement of a plumb bob from leveled car position.

Weight measurements were made at eight tipped positions each side of center. These measurements provided a means of eliminating errors caused by frictional resistance to tipping. Differences of load cell readings were plotted against plumb bob displacement, thus producing a hysteresis loop, Fig. 2, from which corrected weights were determined. A similar set of readings was obtained by tipping the other end of the car from side to side. The longitudinal centerline of the car was kept level by lowering one jack and raising the other equal amounts when tipping the car. Center of gravity computations for the car are given in Fig. 3.

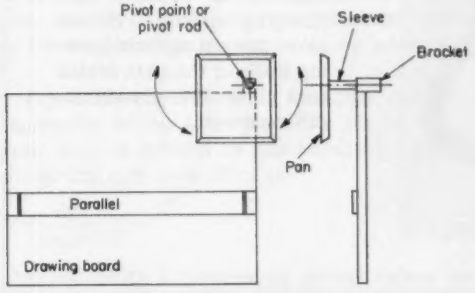
Tips and Techniques

Triangle Serves as Beam Compass

By drilling a series of small holes in a triangle an extremely useful beam compass can be made. To use the triangle as a compass, place a divider point in one of the drilled holes and insert the pencil point in another hole which is at the desired radius. Then by moving the pencil point a circle is drawn. This method has proved to be much more convenient than trying to find a large circle template or even using a beam compass. Any weight or color pencil is easily used without the bother of inserting the lead in the compass.—STEPHEN HSU, *Highland Park, Mich.*

Instrument Holder

There never seems to be any free space for instruments on the drawing board, particularly when a parallel-ruling straightedge which extends to both edges of the board is used. A solution to this problem is to mount a shallow cakepan perhaps 10 by 15 in. atop a sleeve at either the upper left or upper right corner of the board. A small block or bracket is first attached to the corner of the board. All instruments can be kept in the pan. The pan should be mounted to pivot. It can then be swung out of the way if necessary.—WILLIAM E. LOCKE, *Cincinnati, O.*



Sliderule Shortcut

Calculation of linear or surface speeds with a sliderule may be simplified by making a small mark on the C scale at the value 3.82. This simplification is possible because

$$S = nD\frac{\pi}{12} = \frac{nD}{3.82}$$

where S = linear speed, fpm; n = angular speed, rpm, and D = diameter, in. The method eliminates one multiplication step.—P. A. BRILL, *Marblehead, Mass.*

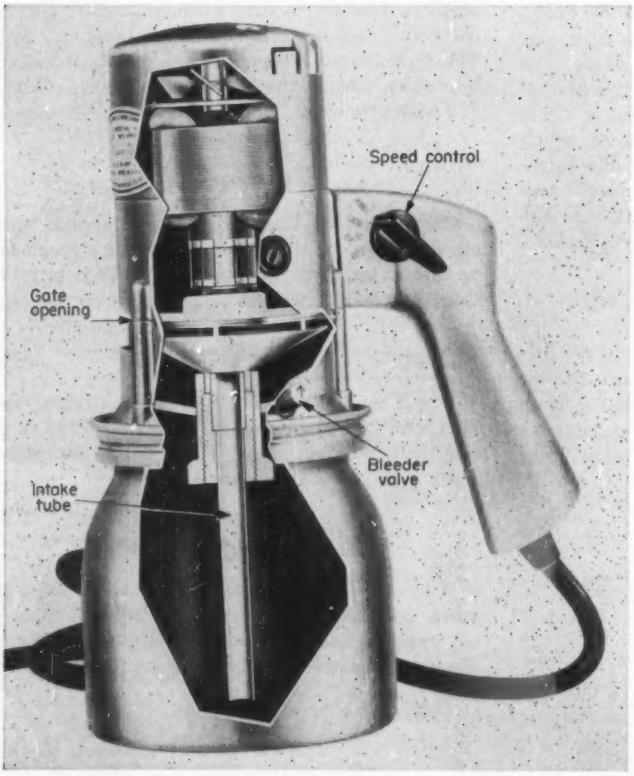
Measuring Diameters

A circle template used as a *go, no-go* gage gives more accurate measurement of outside diameters of parts than does scaling.—KENNETH KANTER, *Ford Instrument Co., Long Island City, N. Y.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Spray Gun Throws Paint

PAINT is thrown by a centrifugal impeller from a recently introduced paint spraying device. A self-contained electric motor spins the impeller at a maximum speed of 22,000 rpm to pump paint from the reservoir and hurl it at the work. Labelled Rogers Rotary Magic Painter, the device is produced by Martin Stove and Range Co. The unit is said to be suitable for use with any water or oil base paint and may also be used to spray oil on finished parts. Total weight is 3 lb.



Paint application rate is controlled in three ways. Three motor speeds are controllable by a switch on the hand grip to give three basic delivery rates. A bleeder valve can be used to permit a controlled amount of air to bleed into the intake tube and thus modify the spray characteristic. The third method for controlling spray is by a sliding gate which controls the actual paint discharge area. Paint is discharged from the impeller around a good part of the periphery. The gate determines how much of the impeller is actually discharging paint. Excess paint thrown against housing walls or the gate drains back into the aluminum-can reservoir.

A suggested method for defining

Metering Valve Characteristics

By Bernard Beaman
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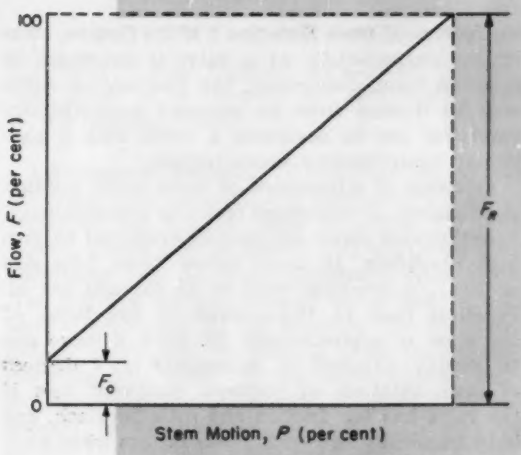


Fig. 1—From this characteristic flow curve for a valve with a linear characteristic, controllability can be derived. Range or rangeability is, by definition, the ratio of maximum to minimum controllable flow.

PRECISE control of fluid flow is often an important hydraulic system requirement. Selection of a metering valve to meet this requirement may often be difficult. This is particularly true when only typical flow characteristic curves are available as selection guides.

In the development of accurate metering valves it has been found that there is a lack of language or accepted standards to define the degree of precise control which they offer. Therefore, it seems that some quantitative definition of this quality, generally referred to as controllability, would be of real help in analyzing valve performance. This article discusses one possible method for precisely defining valve performance.

Prime characteristics of any metering valve are its capability of covering a particular range of operation or flow rates—*rangeability*—and the quantitative extent to which the valve can control flow over the entire operating range—*controllability*. Controllability must be defined throughout the operating range, not at one or only a few flow values. Both of these characteristics are closely related and both must be defined in order to define valve performance adequately.

Controllability: Ratio of smallest possible flow increment which can be readily set to the actual flow rate is defined as controllability. Mathematically this may be written as

$$Y = \frac{dF}{FdP} \qquad (1)$$

Controllability equations of actual valves may be

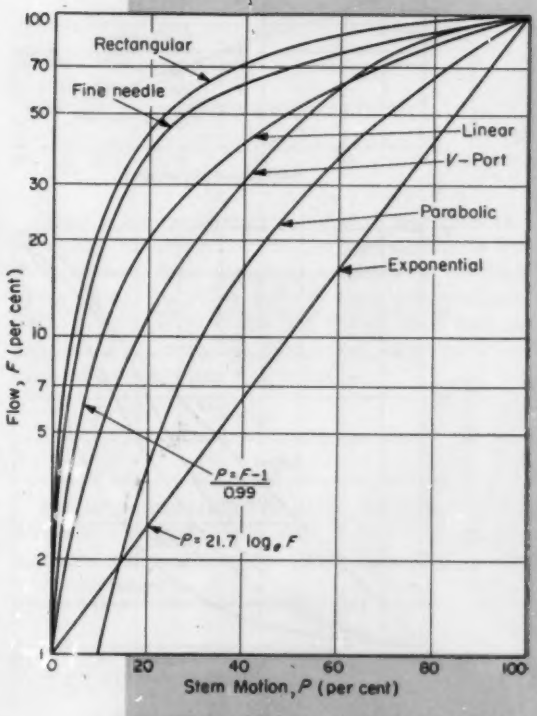


Fig. 2—Some typical metering valve characteristic flow curves. All curves are for a constant pressure drop across the valve.

easily derived from Equation 1 if the flow vs. stem motion characteristic of a valve is expressed in equation form. Conversely, the flow-motion curve may be derived from an assumed controllability curve for use in designing a valve with a particular controllability characteristic.

Precision of adjustment of valve spool position is, of course, an important factor in controllability. Fine-threaded stems are usually employed to give high resolution. In small valves (1-in. tube size or less), a practical limit is 48 threads per in. Practical limit to the number of full turns of the stem is approximately 20. Such a valve can be readily adjusted in increments of 7 degrees of stem rotation, or perhaps somewhat less if the valve has low friction and little backlash, and is hydraulically balanced. These factors when combined allow the valve to be set to 0.1 per cent of full motion.

Internal construction of a valve must be as precise as the external adjusting means if precision of metering equal to 0.1 per cent is to be attained, since 0.1 per cent of total motion of ½-in. is 0.0005-in. All other portions of a valve would have to be machined and finished to tolerances, concentricities and squareness consistent with this order of motion.

Rangeability: Ratio of maximum to minimum controllable flow of a metering valve may be written

$$R = \frac{F_R}{F_0} = \frac{100}{F_0} \qquad (2)$$

Thus, a valve which will reduce flow to 1 per cent of rated flow has a range of 100. However, since controllability is important, the only portion of the range which should be considered is that

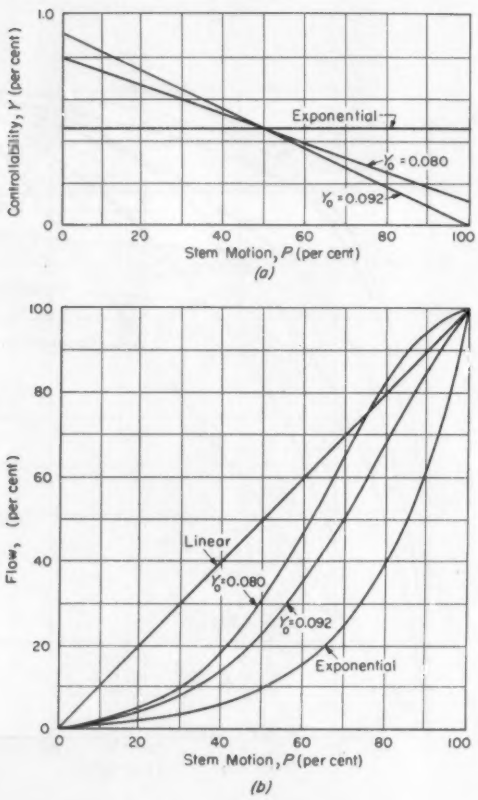


Fig. 3—Controllability curves, *a*, for modified exponential valves show that for this particular family $Y_0 = 0.092$ is a definite limit. Any larger value would cause some portion of the curve near $P = 100$ to be negative or imaginary. Characteristic flow curves derived from the controllability curves are compared with linear and exponential characteristics at *b*.

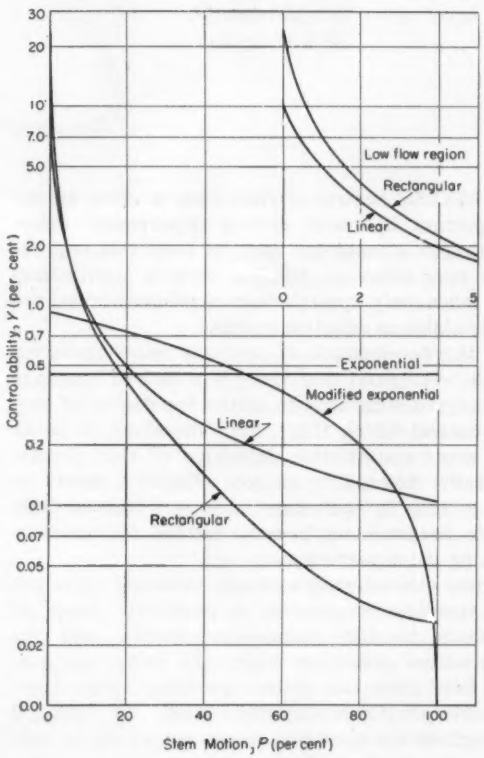
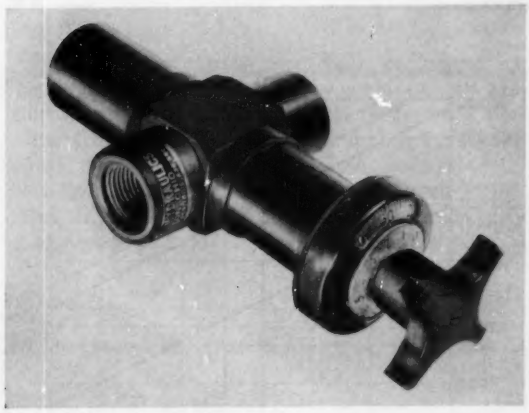
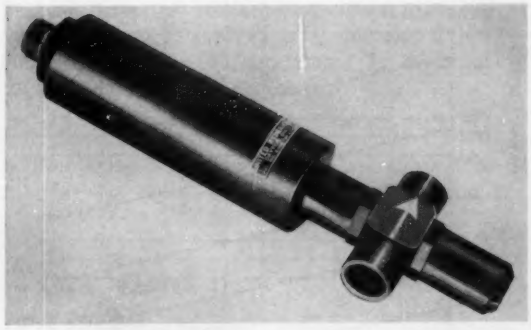


Fig. 4—This group of controllability curves at constant pressure for valves having a nominal range of 100 shows that an exponential valve has constant controllability over the range. Linear and rectangular types show poor controllability below 20 per cent rated motion and better controllability than the exponential type for stem motion greater than 20 per cent. A modified exponential type combines some of the desirable characteristics of both.

over which the controllability requirement is met.

To illustrate this point, consider a valve which at constant pressure drop is required to control flows from 0.1 to 10 gpm. These figures indicate the range, or rangeability, to be 100. However, if an adjustment increment of 1 per cent of rated flow is assumed and this increment is constant over the range of the valve, the increment represents 100 per cent flow variation at minimum flow. This can hardly be called control. The practical range of such a valve would not, therefore, be the aforementioned 100. If, on the other hand, the control increment were a constant 1 per cent of actual flow, a flow variation of 0.001 gpm at minimum flow is possible. Such small variations are rarely, if ever, required. At any rate the practical range of a valve is not necessarily equal to the nominal range.





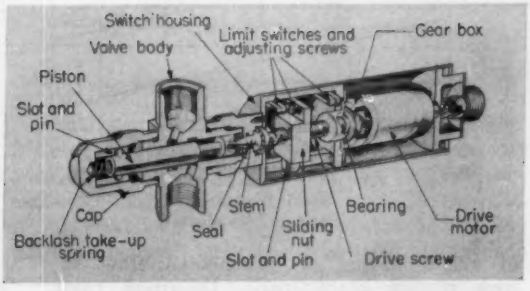


Fig. 5—Motorized and manually operated versions of a metering valve with an exponential flow characteristic have been designed and constructed to verify the conclusions reached in this analysis of controllability and rangeability. Performance curves for these valves are shown in Fig. 6.

Performance Analysis: To illustrate the manner in which controllability and rangeability may be evaluated and applied, these quantities for some typical valves will be derived and discussed. Controllability may be readily calculated from Equation 1 if the characteristic curve of flow vs. motion is expressed as an equation. Or the flow-motion curve may be derived from an assumed controllability curve. If the characteristic flow-motion curve cannot readily or simply be expressed as an equation, controllability may be derived by graphical or step methods.

From the curve of flow F vs. stem motion P for a straight line valve, Fig. 1, the equation is

$$\frac{F - F_0}{P} = \frac{100 - F_0}{100} \tag{3}$$

This may also be expressed as

$$F = F_0 + \left(1 - \frac{F_0}{100}\right) P \tag{4}$$

Substituting this value for F in Equation 1 and integrating,

$$Y = \frac{1 - \frac{F_0}{100}}{F_0 + \left(1 - \frac{F_0}{100}\right) P} \tag{5}$$

Since a low numerical value of Y indicates that flow can be controlled within narrow limits and it is evident from Equation 5 that Y is inversely proportional to P, it follows that controllability of this valve is poor for low values of P and improves as P increases. Maximum value of Y occurs, of course, when $P = 0$ and is

$$Y_0 = \frac{1 - \frac{100}{F_0}}{F_0} \tag{6}$$

For an exponential-type valve, the flow vs. stem movement characteristic, Fig. 2, is a straight line on semi-log co-ordinates. This exponential rela-

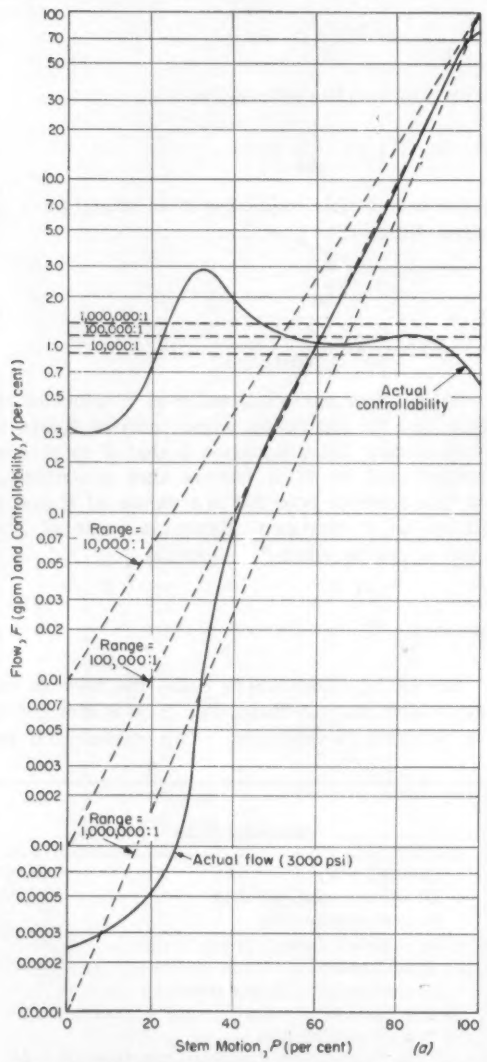
Nomenclature

$b = Y_0 - Y_R$
F = Flow rate, per cent
F_0 = Minimum flow
F_R = Rated flow
K = Constant
P = Stem motion, per cent
R = Range
Y = Controllability
Y_0 = Controllability at minimum flow ($P = 0$)
Y_R = Controllability at rated flow ($P = 100$)

Table 1—Range and Controllability Comparison

Valve Type	Range	Controllability		Flow		Adjustment Increment			
		Maximum (per cent)	Minimum (per cent)	Max. (gpm)	Min. (gpm)	Maximum (gpm)	Maximum (per cent)	Minimum (gpm)	Minimum (per cent)
Exponential	10	0.23	0.23	10.0	1.0	0.023	0.23	0.0023	0.023
	100	0.46	0.46	10.0	0.10	0.046	0.46	0.00046	0.0046
	1000	0.69	0.69	10.0	0.010	0.069	0.69	0.000069	0.00069
	10,000	0.92	0.92	10.0	0.001	0.092	0.92	0.0000092	0.000092
	100,000	1.15	1.15	10.0	0.0001	0.115	1.15	0.00000115	0.0000115
Linear	5.6	0.082	0.46	10.0	1.79	0.0082	0.082	0.0082	0.082
	10	0.09	0.9	10.0	1.0	0.009	0.09	0.009	0.09
	100	0.099	9.9	10.0	0.10	0.0099	0.099	0.0099	0.099
	101	0.0991	10.0	10.0	0.0991	0.00991	0.0991	0.00991	0.0991
	201	0.0995	20.0	10.0	0.04975	0.00995	0.0995	0.00995	0.0995
	1000	0.0999	99.9	10.0	0.010	0.00999	0.0999	0.00999	0.0999
Rectangular	45.7	0.026	10.0	10.0	0.219	0.0026	0.026	0.0219	0.219
	89.2	0.026	20.0	10.0	0.112	0.0026	0.026	0.0224	0.224
	100	0.026	23.5	10.0	0.10	0.0026	0.026	0.0235	0.235
	1000	0.026	230.0	10.0	0.01	0.0026	0.026	0.0230	0.230
Modified Exponential	100	0.00	0.92	10.0	0.10	0.0	0.012	0.00092	0.0092
	100	0.12	0.80	10.0	0.10	0.012	0.12	0.00080	0.0080

Constant pressure drop and stem motion resolution of 0.1 per cent are assumed.



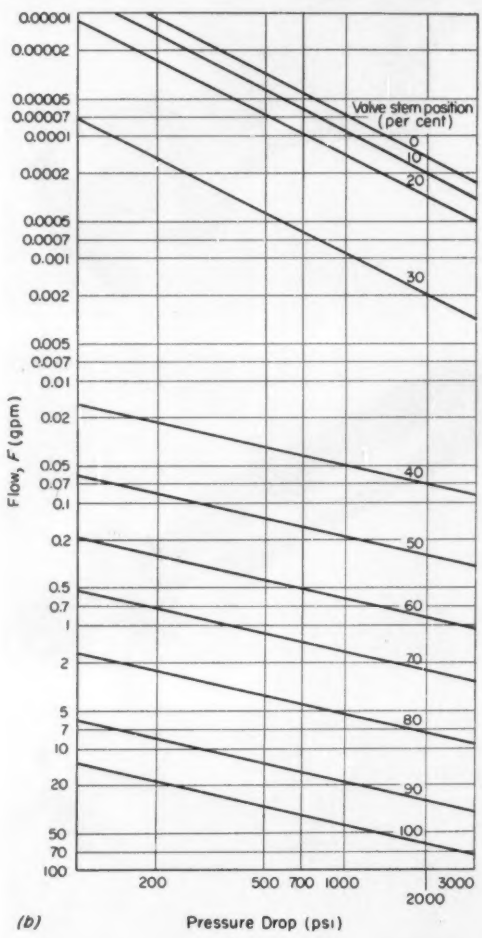


Fig. 6—Characteristics of an actual valve are compared at *a* with the theoretical performance of valves having an exponential flow vs. stem motion characteristic. Departure from theoretical controllability by the actual valve is of the order of 1½ per cent in the region of 25 to 45 per cent stem motion. At *b* are flow vs. pressure drop characteristics for various stem settings.

tionship may be expressed in two ways.

$$F = F_0 e^{K/P} \tag{7}$$

$$P = K \log_e \frac{F}{F_0} \tag{8}$$

Since the curve passes through $P = 100$ and $F = 100$, K may be evaluated using Equation 7 or 8 with Equation 2, and is

$$K = \frac{100}{\log_e R} \tag{9}$$

This demonstrates that assigning a value to R or E_0 defines K and establishes the characteristic flow curve. Controllability for the exponential valve from Equation 1 and 7 or 8 is

$$Y = \frac{1}{K} \tag{10}$$

Preceding derivations have been performed using a given characteristic flow equation. As previously stated, it is also possible to derive a flow curve from given controllability limits. To demonstrate this, assume straight-line controllability variation with P is desired over a given range. First, let $Y_0 - Y_R = b$. Then the controllability at any value of P is

$$Y = Y_0 - \frac{b}{100} P \tag{11}$$

By integration of Equation 11,

$$\log_e F = Y_0 P - \frac{b}{200} P^2 \tag{12}$$

This defines the characteristic flow curve. Since the curve passes through $P = 100$ and $F = 100$, these values may be substituted in Equation 12 to find the following relationship:

$$Y_0 = 0.046 + 0.5b \tag{13}$$

Combining Equations 11 and 13 allows b to be eliminated and results in

$$Y = Y_0 - \left(\frac{2Y_0 - 0.092}{100} \right) P \tag{14}$$

A family of curves on a graph of controllability vs. stem motion is defined by Equation 14. Assignment of a value to Y_0 defines Y for all values of P. Lines corresponding to $Y_0 = 0.092$ and $Y_0 = 0.080$ have been plotted in Fig. 3*a*. While the value 0.080 is a purely arbitrary selection, 0.092 is a definite limit since any value larger than this would result in negative or imaginary values of Y for values of P of or near 100. Integration of Equation 14 results in the equation for the characteristic flow curve. Characteristic flow equations for values of $Y_0 = 0.092$ and $Y_0 = 0.080$ are

$$\log_e F = 0.092P - 0.00046P^2 \tag{15}$$

$$\log_e F = 0.080P - 0.00034P^2 \tag{16}$$

Curves corresponding to Equations 15 and 16, Fig. 3*b*, are designated as modified exponential curves.

Consideration of a group of controllability curves for a nominal range of 100, Fig. 4, show that the exponential type of valve permits control to a constant value of 0.46 per cent over the entire range. Linear and rectangular types show poor controllability below 20 per cent of rated motion and better controllability than the exponential type above this figure. Values of rangeability for specific controllability limits, Table 1, show that range of linear and rectangular valves is severely curtailed if any reasonably low limit is placed upon controllability. It is apparent from these data that valves for extremely high ranges must be of the exponential or modified exponential type.

Based upon these findings, an experimental valve, Fig. 5, has been constructed. Actual performance curves for this valve are shown in Fig. 6.

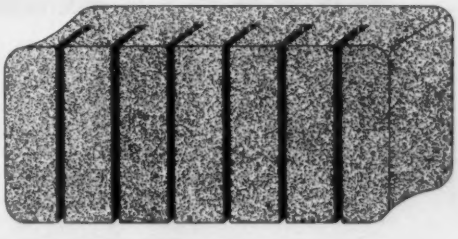
Tips and Techniques

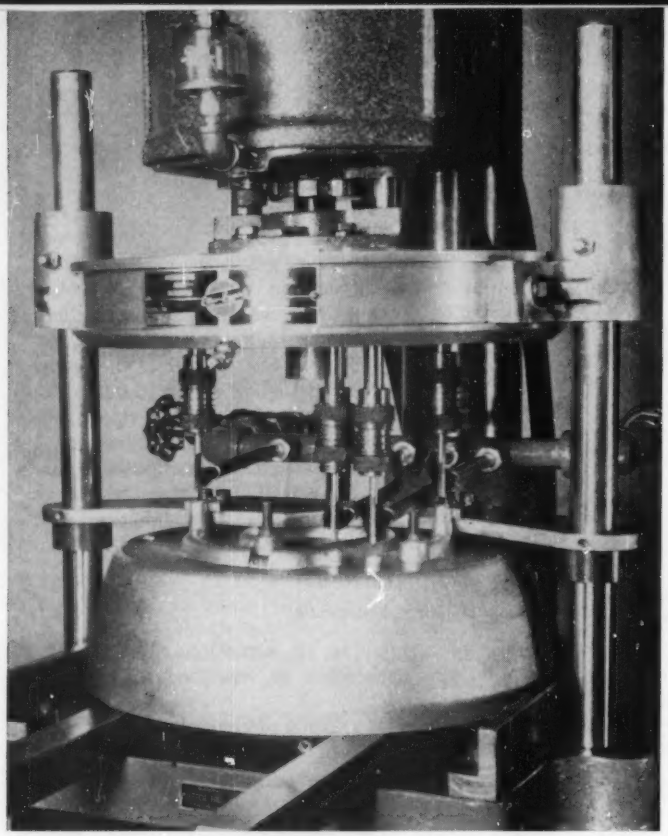
Keeping Drawings Clean

Drafting machine and T-square blades can contribute to smudged drawings as much or more than various other instruments. To prevent this, make two hairpin-shaped clips of 1/32 by ½-in. spring steel and slip on the T-square or drafting machine blades. Only the clips will then touch the drawing—EUGENE GESSNER, *Towson, Md.*

Pencil Cleaner

A block of felt such as an old blackboard eraser with a series of parallel grooves in the face has proved to be very efficient for removing graphite dust from pencil points after sharpening. Pencil point is simply run through one of the grooves after sharpening.—HOWARD LEVY, *Brooklyn, N. Y.*





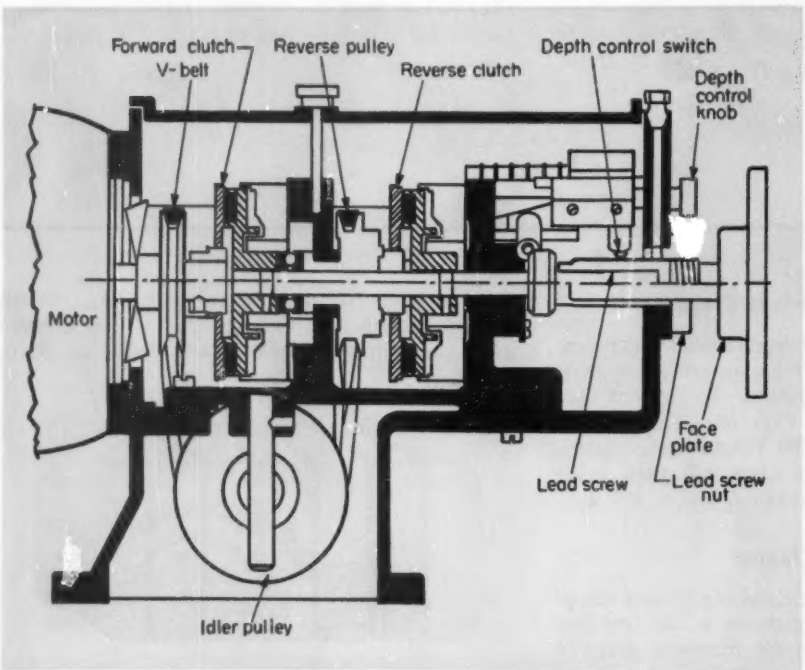
CONTEMPORARY DESIGN

Magnetic Clutches Provide Fast Reversing

PRACTICALLY instantaneous reversal of rotation is provided in a recently introduced lead-screw tapping unit by using two magnetic clutches for reversing. This arrangement permits the drive motor to run continuously. Therefore, time to decelerate the motor and accelerate in the reverse direction is eliminated. Tapping unit is a product of Ettco Tool Co.; the clutches are made by Warner Electric Brake & Clutch Co.

Clutch operation: Armature of the forward or downfeed clutch is keyed to the continuously running drive shaft. Rotor is mounted on the lead screw and the stationary field is on an internal bracket. Reverse clutch armature is mounted on a sheave driven by a V-belt from a reversing idler pulley and the rotor is keyed to the lead screw. Stationary field of this clutch is also mounted on a bracket.

When the machine start button is pressed, the forward clutch is energized to engage motor shaft and lead screw to drive the lead screw and tap into the work. At the preset depth a snap-action switch is actuated to de-energize the down-feed clutch and energize the reverse clutch. Lead screw and tap then rotate in the reverse direction and run out of the workpiece. At the top of the stroke another switch is actuated to stop the machine.



Torque setting of both clutches may be adjusted by external rheostats to provide controlled torque for various sizes of taps and to prevent tap breakage. Torque settings can be changed while the unit is operating if necessary.

Fig. 1—Typical contact meter-relays. Shown are models with adjustable contact pointers for high-limit control (left), low-limit control (center), and both high and low-limit control (right).

By Paul Saint-Amour
Assembly Products Inc.
Chesterland, O.

Applying Meter-Relays

Combining the functions of both indicating meter and control relay, the contact meter-relay serves as a useful and versatile control-system component. Types, ranges, performance characteristics, and application data are presented here.

CONTACT meter-relays—like all relays—are essentially amplifying devices. In function, however, they perform like a combination of several instruments. First, they detect and indicate very small changes in either current or voltage. Next, when these measured quantities reach a preset limit, the meter-relay contacts lock in, and useful work is effected through the opening or closing of auxiliary circuits controlling larger currents or voltages. Points at which control action is initiated can be simply adjusted over a wide range, and sensitivity of the meter-relay depends, in general, upon the model and purpose of the instrument.

Functionally, the meter-relay combines the actions of a locking relay and a permanent-magnet moving-coil meter (D'Arsonval movement). It can be produced in any of the standard D'Arsonval meter ranges; therefore, any measurement that can be detected and noted on a D'Arsonval meter can be controlled with a meter-relay. The contact action can be used to actuate an alarm, or to turn auxiliary equipment off or on if something happens to the signal. Or it can be used to maintain a process at a given level through intermittent process sampling and on-off control of associated circuitry. Transducers supplying input signals to the meter-relay may be strain gages, differential transformers, thermocouples, Wheatstone bridges, tachometer generators, thermistors, photocells, etc.

Representative contact meter-relays, some actuated by current, others by voltage, are illustrated in Fig. 1. These examples include models with either high or low-limit control points, or with both. In all instruments, the indicating pointer cannot move past the adjustable one. Full-scale movement is usually over 95 angular degrees.

How Meter-Relays Work

In the D'Arsonval meter, current is passed through a coil suspended on jeweled pivots in the field of a permanent magnet. Restrained by hair-

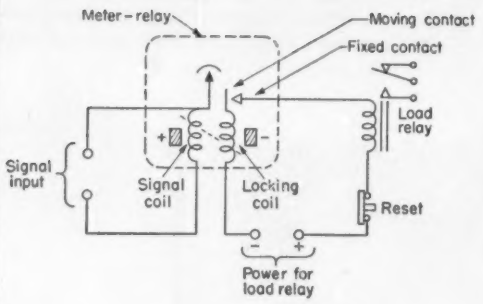


Fig. 2—Basic circuit for contact meter-relay. Locking coil augments contact pressure after signal coil has established initial contact.

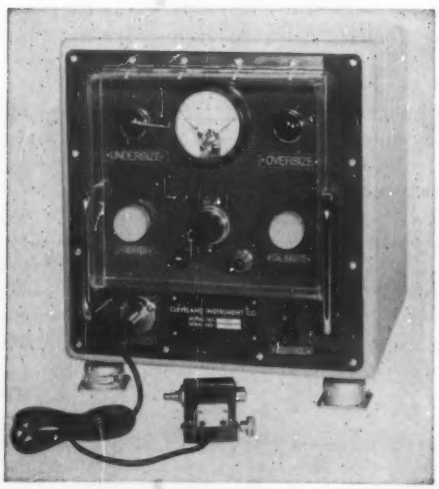
springs, the coil rotates to various positions in proportion to the amount of current passed through it. These positions are indicated on the face of the meter by a pointer carried by the coil. Meters of different sensitivities are produced by varying the strength of the magnet, the number of turns of wire, the shape of the magnet poles surrounding the coil, and the strength of the hairsprings which restore the coil to a zero position when the current is removed.

The meter-relay principle originated when a contact was mounted on the pointer carried by the moving coil, and a mating contact was positioned inside the meter. When the signal current rose or fell to a certain point, the contacts would close or open, controlling slave relays and thereby doing useful work. This arrangement was obviously superior to that requiring a man to watch the meter and push a button at the desired signal level.

Unfortunately, a number of difficulties are inherent in such a simple instrument. A typical microammeter can exert only a few milligrams pressure at the point of contact, and contact so made is usually unreliable. Moreover, such contacts have exhibited a tendency, because of slight arcing, mechanical wear and natural adhesion, to stick together instead of separating when the signal is removed. Both of these types of failure may not show up immediately—sometimes not until after perhaps 100,000 operations.

To provide reliable contact pressure, some manufacturers (Assembly Products Inc.) provide meter-relays with an extra coil, usually consisting of about 100 turns of fine wire, wound on the same form as the normal signal coil. As illustrated by the basic contact meter-relay circuit in Fig. 2 this extra coil is connected to the contact carried on the moving pointer and to a dc or rectified ac source in series with the load. When the contacts come together—even when hesitantly at high resistance—there is enough current flow through this locking coil to produce a further D'Arsonval effect. This adds torque to the movement of the coil and builds up contact pressure until full current flows, locking the contacts securely together. Without this extra torque, the contact pressure resulting from 10 per cent overdrive (signal past contact point) in a meter-relay with a range of 0 to 100 microamperes will be about 5 milligrams. The locking coil torque—even with no overdrive—increases the pressure to from 1 to 3 grams.

The additional torque also loads the spring on



Automatic gaging unit (Cleveland Instrument Co.) measures and controls the inside diameter of steel cylinders to a tolerance of ±0.00001-inch immediately after they are microhoned. To save production time, gaging takes place in a transfer machine. A cylinder is placed over a mandrel, and the gage head measures the amount by which the mandrel expands. This signal, after amplification, actuates the double-contact, zero-centered meter-relay, which is calibrated in fractions of an inch. Full scale either way from zero is only 0.0004-inch. If cylinder diameter does not fall within the proper limits, relays are actuated which (1) turn on either undersize or oversize warning lights, (2) signal an automatic correction to the microhoning machine in time for it to catch the next cylinder, and (3) cause the transfer machine to reject the cylinder into a bin instead of taking it to the next operation.

which the adjustable contact is mounted. When the current flow through the locking coil is interrupted, the loaded spring kicks the contacts apart with a positive action that prevents sticking.

Construction of moving coil, contact and adjustable contact mounted on a spring is shown in Fig. 3. This contact design combines the balanced press-together and kick-apart action.

Meter-relays do not drop out like conventional relays when current through the signal coil is reduced. To get on-off action, a holding circuit with an automatic interrupter is generally used, Fig. 4. Meter contacts are unlocked periodically —e.g., by shorting the locking coil—to sample the signal current. If the signal is still up to the control point, the meter contacts close tightly again and lock quickly. Drop out of the load relay is delayed so that it does not open during this brief interruption cycle. If the signal has dropped, however, the meter contacts remain separated and the load relay releases.

Nonlocking circuit applications for meter-relays —such as firing grids of thyratrons—have, in general, been unsuccessful because of low coil currents. Nonlocking contacts may work, however, when (1) the signal rises above and falls below the point of contact abruptly, (2) the contact load is less than 10 microamperes, (3) the open-circuit voltage is less than 10 volts, and (4) a high-torque—1 milliampere or higher—movement is used. Even when these conditions are met, limited life should be expected.

Ranges and Performance

Current-sensitive meter-relays can be built with full-scale movement over 95 angular degrees, with sensitivities ranging from 0 to 5 microamperes with 12,000-ohm coil to those with sensitivities of 0 to 50 amperes with a coil resistance less than 1 ohm. Both dc and ac meter-relays are available in this entire range, with ac meters having higher resistance because of the self-contained rectifiers. Power consumption is in the lower microwatt range.

Voltage-sensitive meter-relays are available with scale values from 0 to 5 millivolts at 10 or 20

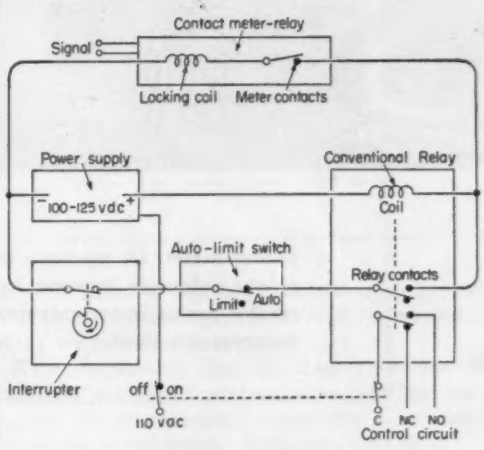


Fig. 4 — Block diagram illustrating a high-limit, automatic-reset meter-relay circuit with interrupter. Intermittent closing of interrupter contacts periodically shorts out the locking coil, allowing the meter-relay contacts to open if the input signal has varied from the limit point.

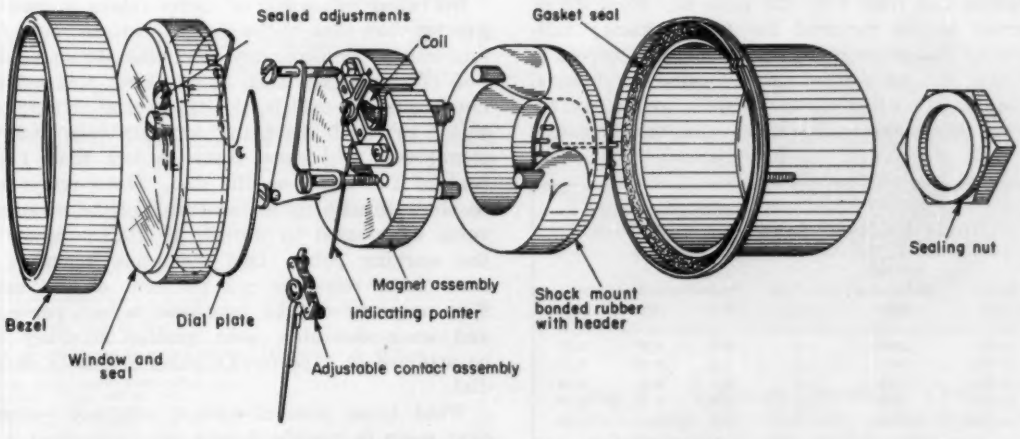
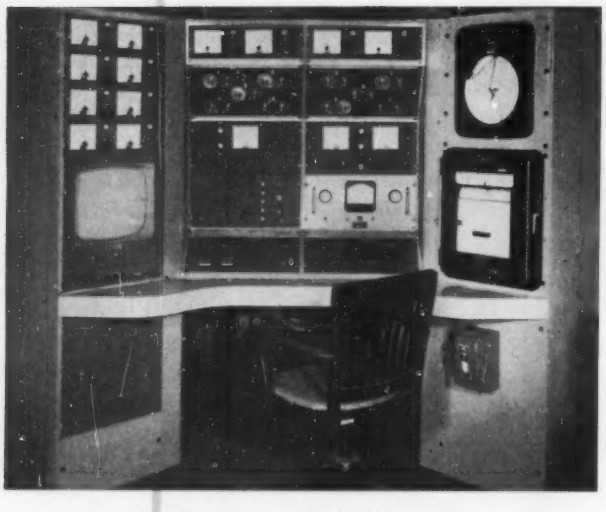


Fig. 3—Exploded view of typical meter-relay.



Meter-relays are used as primary components of the control apparatus at the new nuclear-reactor development laboratory of the Battelle Institute. Panel shown provides all controls found in a full-scale atomic power plant. Meter-relay sets operate in response to currents that are functions of the amount of nuclear fission occurring in the critical assemblies being studied. One set of meter-relays monitors the gamma radiation level directly from a gamma rate meter, and actuates relays that operate warning and safety mechanisms. Another set receives a low-level current from an ion chamber electrometer whose function is to measure the rate of neutron production. The third set operates directly from the capacitor differentiating circuit in the period meter. (A reactor's period is the number of seconds necessary for its power output to increase by a factor of 2.718). These meter-relays show the reactor period in seconds and operate warning and safety devices if the period becomes too short.

ohms, and extending to readings of 0 to 500 volts with sensitivities of 100,000 ohms per volt. Voltage-actuated meter-relays can be obtained in either dc or ac models. However, ac units are not available in the low-millivolt range; practical limit is 0 to 250 millivolts. Step-up transformers can be used to increase the ac signals to the meter-relays. Shunts and transformers can be used for higher current and voltage readings.

Contact ratings on any of the meter-relays just described can be anywhere from 1 to 150 milliamperes and from 6 to 125 volts dc. Pure direct current is not required for the contacts; half-wave or full-wave rectified alternating current is suitable, but unrectified ac will cause detrimental arcing and welding. Below 6 volts, reliability becomes questionable; above 125 volts, the capacitive effect will cause contacts to pull in before the actual contact point is reached. The number of turns of wire contained in the locking coil is determined by the current expected to flow through it.

A word of caution regarding ratings: for proper operation, meter-relay contacts should never be overrated or "safety-factored." If current through the contacts is that for which the meter-relay is designed, pull-in and kick-out will be as desired. Expected life of the contacts, if properly rated, is between 10 and 20-million cycles.

Table 1—Meter-Relay Response Time

Range (μa)	Internal Resistance (ohms)	Overshoot (%)	—Response Time (sec)— 99%*	80%*	66%*
0–20	2850	3–5	0.5	0.37	0.32
0–100	1050	<1	0.7	0.36	0.27
0–250	650	<1	0.6	0.27	0.20
0–500	100	<1	0.5	0.25	0.17
0–1000	100	<1	0.3	0.17	0.13

*Per cent full scale.

Operating accuracy of meter-relays is usually greater than that of the dial indications; both factors can be considerably improved through addition of special features. In all cases, point-of-contact accuracy—that is, the differential between the signal that will leave the contacts open and the signal that will close them—is less than 1 per cent of full scale on the dial. Meter-relays can be obtained with up to two-thirds of the maximum value suppressed to provide greater accuracy at the working point. Dial indicating accuracy of most meter-relays is ± 2 per cent of full scale. This accuracy can be improved to ± 1 per cent, and when desirable, even greater accuracy can be attained at a particular point or points on the dial.

What these point-of-contact accuracy percentages mean in specific figures can be illustrated as follows. With a full-scale reading of 10 microamperes and a point-of-contact accuracy of 1

Table 2—Check List of Meter-Relay Application Factors

Contact Data

1. Contact arrangements are defined by function:
   (a) High-limit, adjustable; makes on increase of signal.
   (b) Low-limit, adjustable; makes on decrease of signal.
   (c) Double-contact, adjustable; makes on either increase or decrease.
   (d) Fixed-contact, single or double.
   (e) Special double-contact arrangements such as one fixed and one adjustable, both adjustable by a single knob with fixed separation, or both fixed.
2. Contact ratings available are as follows:
   (a) Standard is 5 to 25 milliamperes dc at 75 to 125 volts dc.
   (b) Lower or higher current ratings than standard use same size contacts but require changes in locking coil. For nonstandard ratings, therefore, state current expected through locking coil and contacts. Do not "safety factor" contacts.
   (c) Special contact treatment is required for operation on less than 75 volts; nominal minimum is 6 volts. More than 125 volts can cause early contact make because of electrostatic attraction between contacts.

Accuracy and Internal Resistance

1. Standard accuracy at normal room temperature is ±2 per cent specified direct current or voltage, ±3 per cent alternating current.
   (a) Standard internal-resistance tolerance is ±20 per cent. Resistance tolerances to ±1 per cent are available for most sensitivities.
2. Input accuracy of 1 per cent can be specially supplied for most ranges at extra cost.
3. Thermistor compensation can be supplied in most ranges for accuracy over ambient changes from 0 to 140 F at extra charge.
4. Calibration in both current and voltage can be supplied at additional cost.

Zero Markings

1. Standard zero position is zero left.
2. Special markings and movements, such as zero center, zero right or zero off-center are available.
3. Suppressed zero calibrations, based on suppressing up to 60 per cent of the range of a meter-relay, can be supplied. An example is a meter calibration from 30 to 50 volts.

Range Data

1. Direct current is standard for both current - sensitive and voltage - sensitive meter-relays.
   (a) Ranges of current-sensitive models vary from 0 to 5 microamperes to 0 to 50 amperes.
   (b) Ranges of voltage-sensitive models vary from 0 to 5 millivolts to 0 to 500 volts.
2. Alternating-current models are available in most ranges.
   (a) Current-sensitive ac meter-relays are available in ranges from 0 to 5 microamperes to 0 to 50 amperes.
   (b) Voltage-sensitive ac meter-relays are available in ranges from 0 to 250 millivolts to 0 to 500 volts. For lower millivolt ranges, signals can be stepped up with transformers.

Mountings

1. Most meter-relays can be mounted in any position.
2. If calibration for a steel (magnetic) panel is requested, specify steel thickness.
3. Meter-relays can be calibrated for mounting on nonmagnetic materials, such as plastics, wood, aluminum, etc.

per cent, a change of 0.1-microampere will actuate the contacts. With a 0 to 5-millivolt scale, the differential can be as small as 0.05-millivolt.

Response time is the interval between the instant signal current or voltage reaches the meter coil and the instant the coil and pointer arrive at a position corresponding to some predetermined fraction of the input signal. In general, the response time of contact meter-relays is approximately the same as that of standard meters, ranging from 100 milliseconds to 10 seconds. Average response times of standard indicating meter-relays in 1/16-inch mounting panels (high-impedance circuits) are shown in Table 1.

With overdriving—for example, where the contacts are set to 40 microamperes and the signal reaches 80 microamperes—response time can be cut to 10 milliseconds. Response time is cut approximately in half when the number of turns of wire on the moving coil is doubled. Practical lower limit, however, is about 20 to 50 milliseconds because of static inertia in the meter system.

Low external impedances will slow down the meter movement, although blocking diodes can sometimes be used to prevent this effect. If desired, response times of almost all ranges of meter relays can be slowed to 5 or 10 seconds by suitable circuitry.

Table 3—How to Select the Meter Relay

Control Problem	Recommended Meter Relay
Automatically maintaining a variable at a given level, such as an on-off control.	High-limit automatic reset. Frequency of interruption can range from four per second to one per hour.
Shut-down and lock when increasing signal reaches a point.	High-limit manual reset.
Shut-down and lock when decreasing signal reaches a point.	Low-limit manual reset.
Pulsing control (light, buzzer, corrective action, etc.) when signal reaches a point.	Self-releasing circuit with either high, low, or double-contact design. Control action ceases when signal is restored to proper level.
Turn on something if signal drops to low point. Turn on something else if signal rises to high point. No control action if indicating pointer is between preset contact points.	Double-contact automatic reset.
Shut-down and lock if signal varies from normal high or low.	Double-contact manual reset.
Turn on something if signal drops to low point. Keep on until signal reaches high point (controlled differential). Turn off at high point. Turn on again when signal drops to low point. Process can be reversed, starting with control action at high point, etc.	Interlocked or cycling.

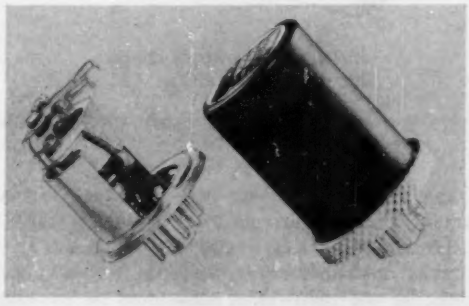


Fig. 5 — Very-high sensitivity (VHS) meter-relay. Enclosed and gasket-sealed, unit has no indicating dial.

If response times are important in a given meter-relay application, factors that should be specified are (1) tolerance on response time, (2) tolerance on calibration, (3) external impedance, (4) allowable overshoot, and (5) internal resistance limitation, if any.

The check list, Table 2, summarizes meter-relay factors that are usually specified for a given application. Meter-relay circuits recommended for certain selected control situations are given in Table 3.

Special Types

Meter-relays are normally designed with a common connection between the signal coil and the locking coil. In some applications, however, it is desirable to bring out these coil leads to separate terminals. Meter-relays with such connections are then known as *isolated* types.

Isolated meter-relays should be used, for example, where there are other instruments in the signal circuit. With an unisolated meter-relay, the locking coil has a tendency to affect the readings of the other instruments when contact is made. Current flowing through the common connection in the unisolated meter-relay may push a sensitive external instrument far up-scale or down-scale, damaging the instrument movement or causing it to read incorrectly.

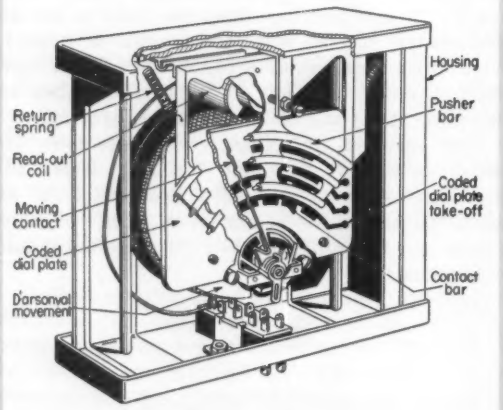


Fig. 6 — Multiple-contact meter-relay (LIAD).

Use of isolated meter-relays is also often required by various other unusual circuit requirements. For example, a load circuit may have a negative ground connection, the signal circuit a positive ground connection, and a high-limit meter-relay is desired. In this case, connections would have to be jumpered.

Isolated meter-relays should not be used to provide protection between signal circuit and contact circuit. If there is danger of voltage breakdown between these two circuits, an isolating transformer should be incorporated in the locking circuit.

New uses for contact meter-relays are being worked out every day. It is expected that this expansion of applications will continue indefinitely. Along with new applications, new types of meter-relays are being developed. Typical of these are the very high sensitivity relay (VHS) and the multiple-contact digital-output meter-relay, (LIAD).

The very high sensitivity relay, Fig. 5, which is internally shock mounted on rubber to withstand jarring and vibration, operates like a conventional meter-relay but has no dial or pointers. Voltage or current setting at which the contacts lock is usually fixed at the factory. Sensitivity of this meter-relay ranges from 0.2-microampere to 10 amperes, or from 0.1-millivolt to 500 volts. Intended for use in aircraft and guided missiles, the VHS has a gasket-sealed, screw-on cover. It plugs into standard octal-type sockets, although other mountings may be obtained.

Prototypes of the LIAD, Fig. 6, are available, although it is still in the developmental stage. It converts analog information to digital form, and its initial applications include telemetering, simple quantitative read-out, automatic production testing or grading, maximum-value reading, or transmission of meter readings to remote locations. In effect, the LIAD takes control action at one of a number of points, or a combination of them that are "preset" by the location of printed circuits.

The LIAD has a D'Arsonval meter movement, but a printed-circuit scale replaces the normal dial. In one type, there is a one-band scale with up to thirty segments. Another model has up to six bands which are divided to produce a modified binary output. In operation, the contacting pointer is positioned by the D'Arsonval coil. The read-out coil is energized either manually or automatically with an interrupter to move the pusher bar and the contacting pointer down on the printed-circuit scale. The output is a unique combination of closures which depends on pointer position.

"We live in an age of technological marvels. We have become so accustomed in our daily life to this technology—our telephone, our automobile, our television set—that we forget how great has become our dependence on scientists and engineers. Most dependent of all is our military establishment, for the weapons of modern war press hard upon the frontiers of human knowledge."—COLONEL O. G. HAYWOOD, *USAFR.*

MACHINE DESIGN
Data Sheet

Nomograph gives numerical estimate of **Galvanic Corrosion**

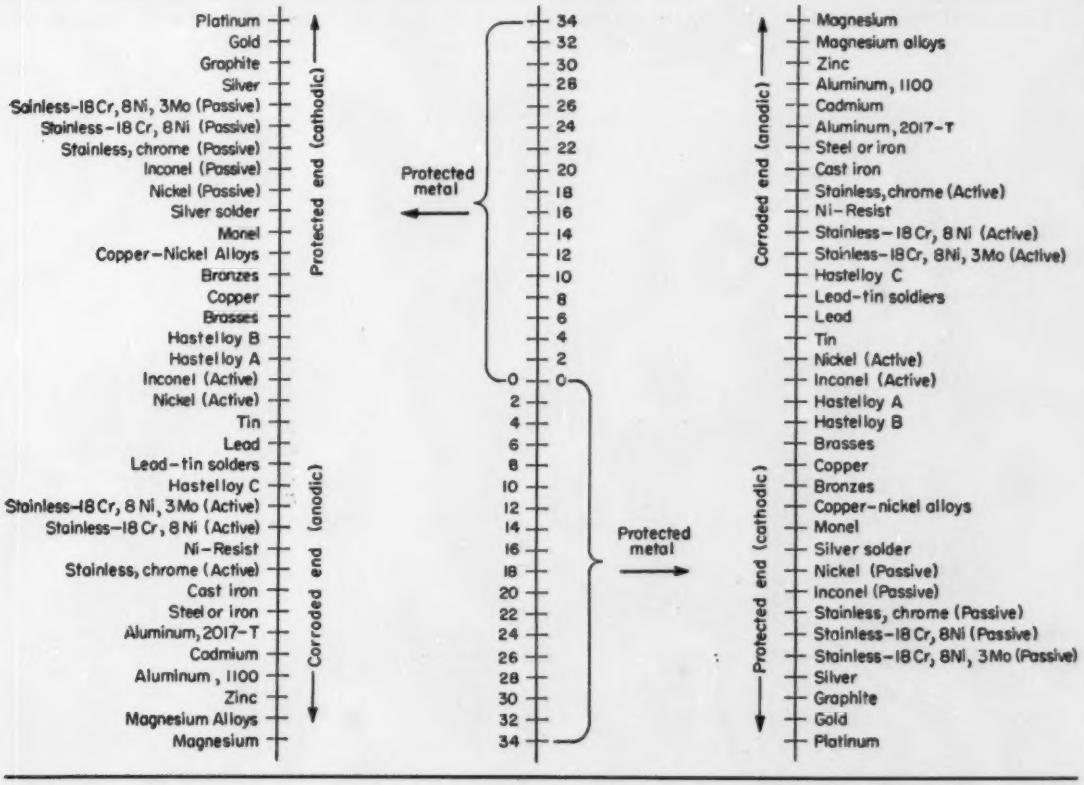
By Harold Blye, *Bellerose, L. I., N. Y.*

WHEN two metals are in electrical contact in the presence of an electrolyte, galvanic corrosion is possible. Metals farthest apart in a galvanic series will corrode most rapidly. Galvanic corrosion may be produced by two entirely different metals or two similar metals differing only slightly in chemical composition or physical condition.

The nomograph offers a clear picture of the possible extent of galvanic corrosion for comparison purposes. A straightedge (or edge of a piece of paper) connecting two metals gives a numerical estimate (arbitrary scale) of amount of corrosion, and also shows which metal will be protected. Also, differences in corrosion rates may be established for different metal combinations.

A greater corrosion rate than indicated will result if a small anode (interface area) is in contact with a large cathode (interface area), since current density is increased at the anode. To help prevent corrosion cells from forming, all cracks, crevices, sharp bends, scale and other surface deposits between interface areas should be avoided where possible.

Example: Connecting *Inconel (Passive)* on the left scale with *Magnesium Alloys* on the right scale yields a numerical value of 26, with the Inconel protected and magnesium alloy attacked. Connecting *Inconel (Passive)* with *Copper-nickel alloys* gives a value of only 4, an obviously better combination for resisting galvanic corrosion.



Designing for Reliability

RELIABILITY of a device is defined as the mathematical probability that the device will perform its design function under the design environments within specified tolerances for the required time interval. After sufficient tests on the device, an estimate of relative reliability can be rendered together with a level of "confidence" in the estimate, which is the probability that the true reliability lies higher than a stated minimum.

For example, if 100 units are tested and one fails, the statistician will state with 97.5 per cent confidence that based upon the sample size (100 units), the reliability of subsequent samples is better than 94.6 per cent. If none had failed, however, the reliability of subsequent samples at the same confidence level is 1.8 per cent higher, i.e., better than 96.4 per cent. As another example, if 20 units are successfully tested, then, at the 97.5 per cent confidence level, the reliability of subsequent samples is estimated to be better than 86 per cent. If, for this example, one is willing to be less confident of his prediction of reliability, say 90 per cent confident, then he could raise the figure for reliability to "better than 89 per cent." The relationship between sample size, number of failures, confidence level, and reliability is shown in Figs. 1, 2 and 3.

With a complex system having many independent components, system failure caused by the failure of any one component means that the reliability of the system is the prod-

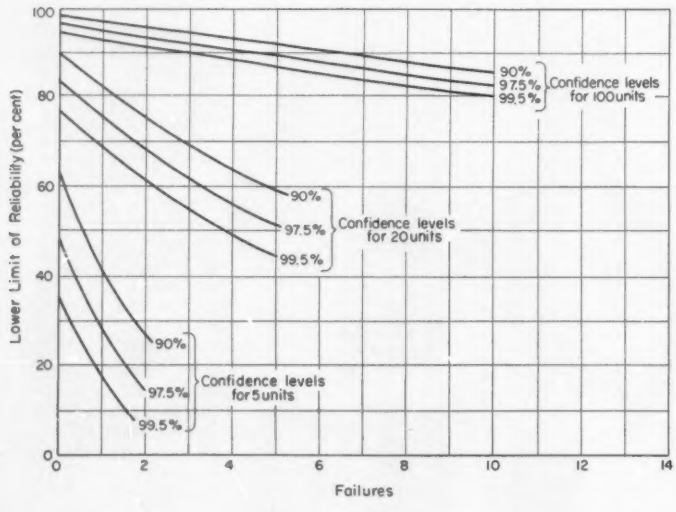


Fig. 1—Relation of reliability to number of failures at several confidence levels and for several sample sizes tested.

By R. B. Wilson

Convair Div.
General Dynamics Corp.
San Diego, Calif.

uct of the individual component reliabilities. In other words, a device with 400 independent components each of which is 99 per cent reliable has a 1.8 per cent chance of full and proper functioning at the crucial moment. This obviously untenable reliability demands that designers exercise an extremely high degree of caution.

As a start on the problem of designing reliable equipment, the designer must consider the requirements of the system of which the equipment is to be made a part. These system requirements dictate the general operating specifications.

Environment: Concurrently, the designer must have a thorough understanding of the environments in which the equipment is to be manufactured, handled, transported, stored, installed, used and serviced. The designer must give consideration to all of the following environmental conditions, selecting to the best of his ability those conditions which are applicable and in which the equipment must perform:

1. High temperature
2. Low temperature
3. Temperature shock
4. Sand and dust
5. Fungus resistance
6. Sunshine
7. Corrosive gases and liquids
8. Altitude
9. Huraidity
10. Immersion
11. Water spray
12. Salt spray
13. Explosive atmospheres
14. Vibration—3 axes
15. Shock—3 axes, 6 directions
16. Acceleration—3 axes, 6 directions
17. Pertinent combinations of the above

In a given design problem some environmental factors relating to the application will be given by specification. The designer must assume, or determine by measurement, if possible, the laws of variation of life with environment for each of the listed environmental factors as applied to each of the components of the equipment. Then, for the applicable environments, numerical values for these design requirements must be established as standards for comparison and evaluation of any proposed designs.

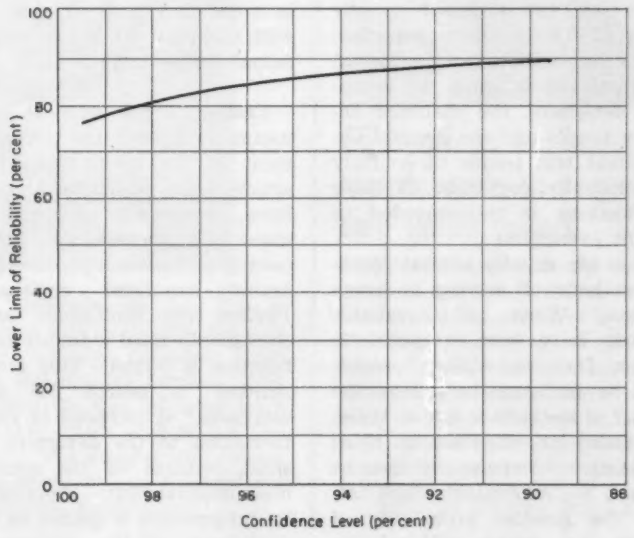


Fig. 2—How reliability is related to confidence level for 20 units tested with no failures.

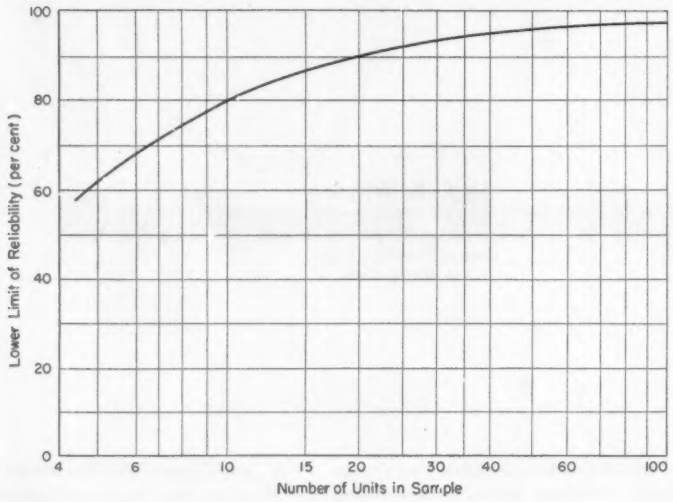


Fig. 3—How reliability is affected by sample size tested with no failures at 90 per cent confidence level.

Overlooking one or more of the environments to which the equipment may be subjected is a common initial difficulty. It is well worth the expended effort to prepare, prior to any design effort, equipment specifications in which are set down all of the anticipated environments to which the equipment may be subjected in the course of its life, from manufacture to eventual discard. A formal procedure encouraging the equipment designers, the customer relations people and the product development test people to be fully and mutually cognizant of these specifications is recommended to prevent oversights.

There are usually several potential methods of solving a design problem. When all available methods have been prepared in written form, a culling process must be initiated to reduce the number of methods to two or three. A detailed investigation of these remaining methods should then be pursued to determine which affords the greatest probability of success; i.e., which will reliably yield the required equipment life in the given environments, as balanced against cost, complexity, development time, available materials, etc. Finally, a single method is selected. This method should be analyzed bit by bit, outlining every implied limitation as well as advantage. Every ambiguity should be amplified until resolution can be achieved—arbitrarily when absolutely necessary. All the data relating to the selected method and its aspects should be summed up in a design report. The designer, with this report, can now enter the actual design stage.

Testing: The task is by no means over with the accomplishment of the initial design. The article must be subjected to test. Here, a recently fostered technique is recommended — that of testing in increasingly severe laboratory-simulated environments (within the limitations of test equipment) until a failure or malfunction is forced. This program, entitled "a search for critical weakness," is intended to yield information to the designers as to what features of the equipment need improvement. Simultaneously, information is gained as to the usefulness of the equipment in these environments, as well as the degree of relative reliability of a piece of equipment at any given level of environmental severity up to the failure point.

The design of this search-for-critical-weakness program is important. This test program should be performed on several samples to get a statistical spread of information. A test sequence must be chosen that most likely will permit the largest number of environmental tests on a given unit before failure of that unit is induced; that is, the least damaging test should be performed first, and the most damaging test last.

It is generally felt that temperature, acceleration, and vibration are the most applicable environments of the list presented earlier in which it is well to test for critical weaknesses. Past experience has shown that this sequence, that is, temperature, acceleration and vibration, is the most logical. Electronic equipment may go out of tolerance with change in temperature, a "critical weakness," but will return to tolerance with return to normal operating temperature. Mechanical equipment may suffer a change in fits from differential expansion and contraction, but unless a damaging seizure occurs, will return to workable condition upon return to normal temperature. The same sort of analysis can apply to environmental acceleration. However, vibration is degrading,

BEARING TIPS by McGill

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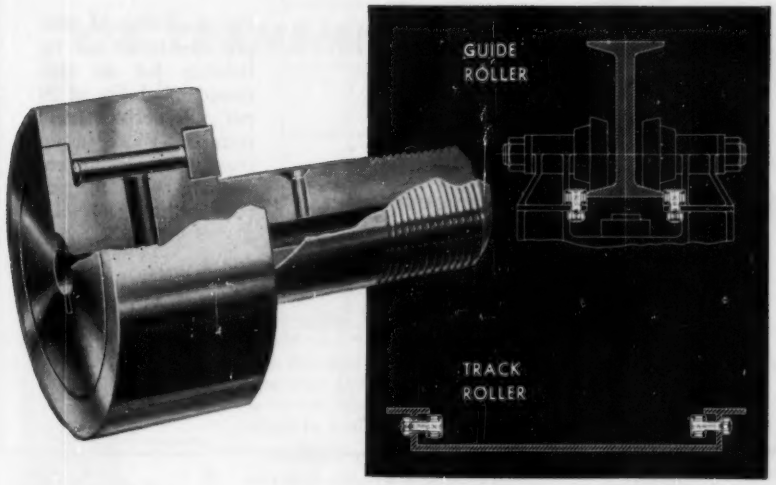
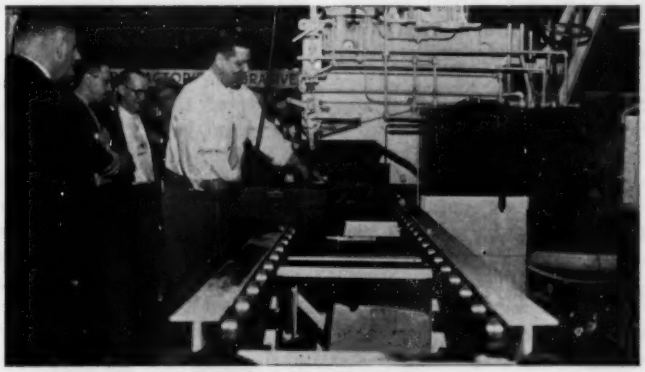


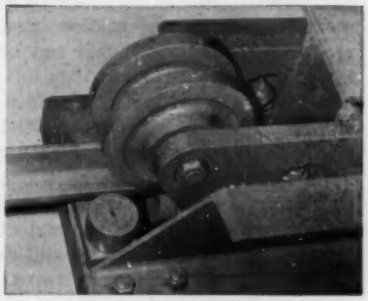
Obtain freer rolling, improved alignment and positive side thrust

In guide and support roller applications CAMROL Cam Followers insure free rolling action and positive side thrust while eliminating the wear of more costly flanged wheels. Then, too, they provide improved alignment and low starting and running friction with high unit load and shock capacity, especially at low speeds as track rollers. Lubrication is simplified and maintenance can be reduced to a minimum in these applications. Specify the interchangeable sealed SGR series for added protection against contamination.

CAMROL CF bearings provide friction-free track rollers for automatic mold blower



McGill CAMROL CF rollers are used as guide rollers to form a mold conveyor in the Beardsley & Piper MBS-20 Mold Blower. The machine blows and squeezes cope or drag in a single automatic operation, handling up to 4 molds per minute. The CAMROL CF bearings replaced less efficient friction rollers in this application. Although, the duty here is rather light and speeds slow, the cam follower bearing provides lesser starting and running friction. This helps speed the flow of work from the machine, which must be fast and automatic. The integral stud feature eases assembly and its standard design simplifies procurement.



CF bearings minimize maintenance as crane side guide rollers

McGill CF cam follower bearings serve as side guide rollers in overhead cranes manufactured by Louden Machinery Company of Fairfield, Iowa. Freedom from maintenance, a time saver because of the inaccessibility of the bearing when the crane is in operation, is an important advantage of the cam follower bearing.

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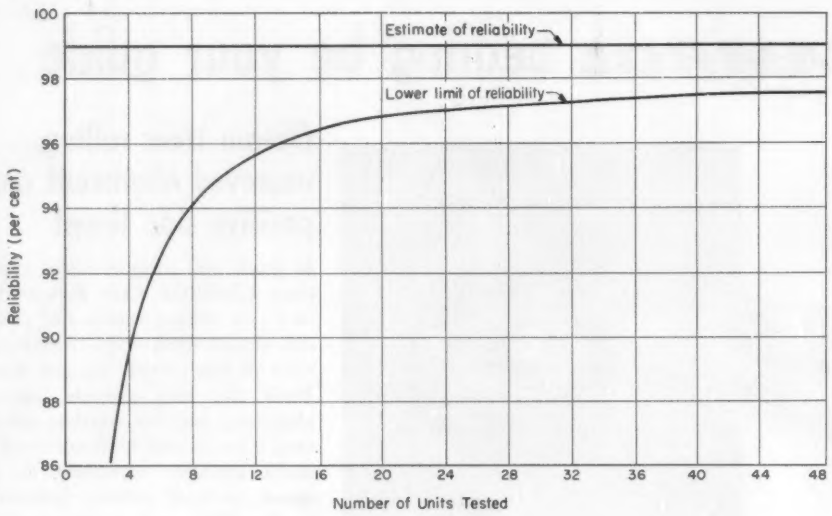


Fig. 4—Effect of sample size tested on reliability for an estimated reliability of 99 per cent derived from tests to failure in increasingly severe environment, at 90 per cent confidence level.

particularly where a structural member is of such section that repetitive bending stresses can be imposed on it in excess of its infinite-life fatigue stress. Surface-stress fatigue life is always limited, also. Therefore, vibration should be the last environment to which the samples should be subjected since degradation of the product is almost certain. If test facilities can be provided, testing in two or more environmental conditions simultaneously will yield information of greater value, inasmuch as actual expected operating conditions would thus be more nearly simulated. In general, the behavior of equipment in the remaining applicable environments can be evaluated by testing one of a kind.

The more samples tested, the more confidence can be attached to a conclusion. There are practical limitations on the number of samples tested, however, such as availability of facilities, availability of samples, cost, time and manpower. Statisticians state that there should never be less than five in the group; the sampling error associated with a smaller sample is too high. As is shown in Fig. 4, there is a diminishing gain in lower limit of reliability per number of units successfully tested that begins to show with sample sizes greater than five. On some critical items, however, it is considered mandatory to run larger sample sizes in order to obtain greater confidence.

Analyzing Failures: Analyses of failures are of great importance in any test program. A qualified test engineer should be present at every "autopsy," if not actually performing the disassembly of equipment in order to find the exact cause of failure. The value of a "failed-parts" analysis is in direct proportion to the level of competence of the personnel involved.

In the usual development program, information on failures and malfunctions or discrepancies in the production and field tests will begin to become available concurrently with the search-for-critical-weakness test program. It is essential to set up an efficient reporting system to correlate information, analyze it, and feed it back to the designer. It is apparent that the simpler the task of preparing such reports, the greater the usefulness of the reporting system.

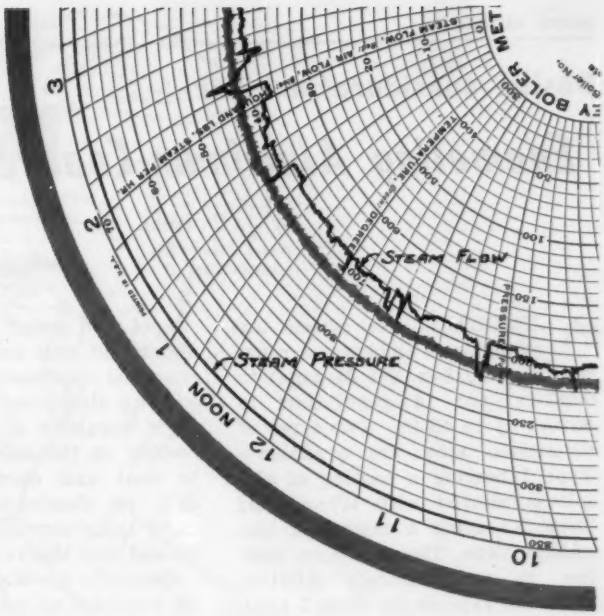
Coupled with the report of the failure or malfunction, there must be available a complete history of the equipment, itemizing any repairs or corrections made during its manufacture, the characteristics of its parts, the cumulative time of operation experienced in applicable environments, the behavior of the equipment parts at receiving inspection, behavior at in-process tests, behavior at final acceptance tests, and so forth.

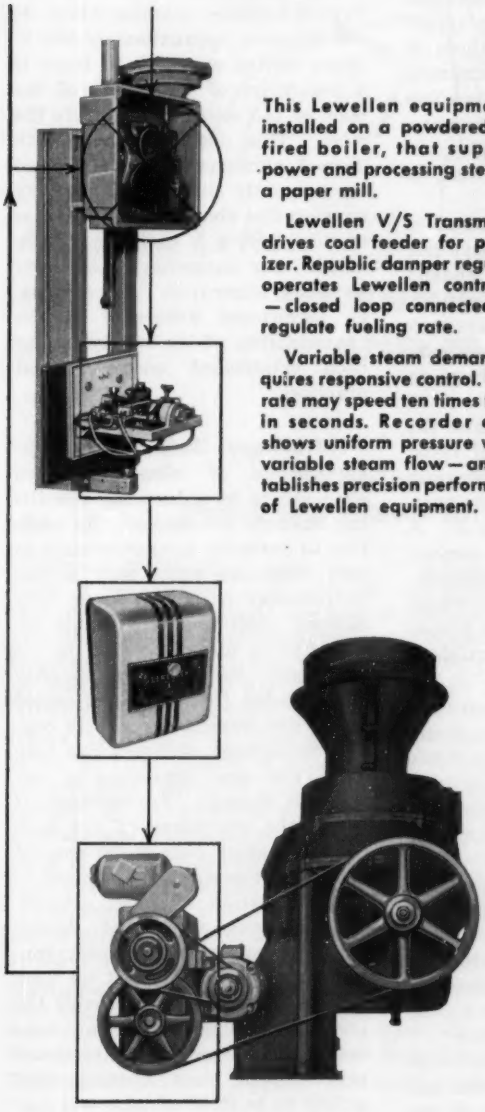
All of this data must be collected and collated. One of the several rapid-sort card-filing systems available can be used profitably for this purpose. With such a card system, trends can be spotted, providing a warning to designers that a change in design is needed.

The designer should not need or be made to feel that it is "his fault" that the equipment malfunctions; rather he should strive for an attitude of complete self-detachment. Personnel involved must approach such a situation with an open mind, asking themselves the question, "What can be done to remedy this problem?"

From a paper entitled "Designing Equipment for Reliability" presented at the American Rocket Society Annual Meeting in New York, November, 1956.

AUTOMATED VARIABLE SPEEDS WITH LEWELLEN V/S TRANSMISSION





This Lewellen equipment is installed on a powdered coal fired boiler, that supplies power and processing steam in a paper mill.

Lewellen V/S Transmission drives coal feeder for pulverizer. Republic damper regulator operates Lewellen controllers — closed loop connected — to regulate fueling rate.

Variable steam demand requires responsive control. Firing rate may speed ten times faster in seconds. Recorder chart shows uniform pressure versus variable steam flow — and establishes precision performance of Lewellen equipment.

Automatic Control of variable speed operated equipment offers greater precision, increased production, and continuous flow of operations.

Lewellen V/S Transmission offer infinitely, accurately variable speeds, in ratings to 60 h.p., speed ranges to 20:1.

Where metering instruments are used, Lewellen Controllers readily adapt to available regulators and servo devices.

Where rotary, oscillating, or proportional machine motions are available, Lewellen Servos implement the operation.

Automatically controlled speeds compensate transient and cumulative fluctuations—translate motions—to maintain product uniformity and continuity . . . frequently the most direct and effective control of the operation.

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Design considerations for

Enameling Aluminum-Coated Steel

By J. E. Sams

Armco Steel Corp.
Middletown, O.

ALUMINIZED steel sheets are available in thicknesses ranging from 0.028-in. (or 24 gage) to 0.081-in. (or 14 gage) and in widths up to 48 in. Two types of aluminized steel are available—Type 1 bearing a coating of aluminum alloyed with silicon, and Type 2 bearing a coating of aluminum alone. The aluminum coating is approximately 0.001-in. thick per side on the Type 1 product and approximately 0.002-in. thick per side on Type 2.

Atmospheric corrosion tests have shown that the aluminum coatings on both types should prove more than adequate to protect the back side of porcelain enameled panels.

Physical Properties: The tensile strength of aluminized steel is comparable to enameling iron and about four times greater than pure aluminum at room temperature. At enameling temperatures this special steel is about ten times stronger than aluminum. As far as expansion is concerned, aluminum-coated steel roughly will behave as if it were a single metal. For example, the equivalent thermal expansion for 20-gage aluminized steel is only a few points above the steel itself. This difference will increase with lighter gages.

Armco's aluminized steel Type 1 can be drawn moderately and up to 180-deg bends can be made providing liberal radii of at least the equivalent of twice the metal thickness are used. The Type 2 product is generally limited to panels requiring no more than right angled bends for flanging. Often a tryout is necessary to determine if the material can make the part. In any case, all fabrication should be done carefully to avoid damaging the aluminum coating. Regular, easily removable lubricants for aluminum may be used satisfactorily with aluminized steel as a help in this respect.

Spot and roller seam welds of aluminized steel may be made and enameled successfully. In spot-welding aluminized steel, there is some expulsion of the aluminum coating on the outer surfaces due to heat and electrode pressure. Still, an aluminum-iron alloy, in itself quite corrosion resistant, is formed over the weld.

Generally speaking, aluminum is an excellent reflector of heat but is a poor radiator, whereas enamel is an excellent radiator of heat but a poor reflector. Such factors may be taken advantage of when using one-side enameling as perhaps in the design of a toaster.

From a durability standpoint the bare aluminum coating will resist discoloration at temperatures up to about 900 F and resist destructive scaling on up to 1250 F. A bulkhead or partition of aluminized steel will not slump at temperatures of 1500 F or better which may be reached when a fire breaks out on board ship or in a building.

Enameling: Enamel preparation is practically the same for aluminized steel as for aluminum. While it is true that the overall expansion of aluminized steel approaches the expansion of steel alone, enamels designed for aluminum have been applied satisfactorily to aluminized steel. Some enamels, of lower expansion, have been formulated specifically for aluminized steel in order to insure having the enamel under an adequate amount of compression at room temperature.

Sometimes there are reactions involving both the base metal and the enamel. Since slurries of the present enamels for aluminum are highly alkaline, it is generally preferred that the time that the enamels are in wet contact with the aluminum coating be minimized. This is aided by an immediate drying or firing operation.

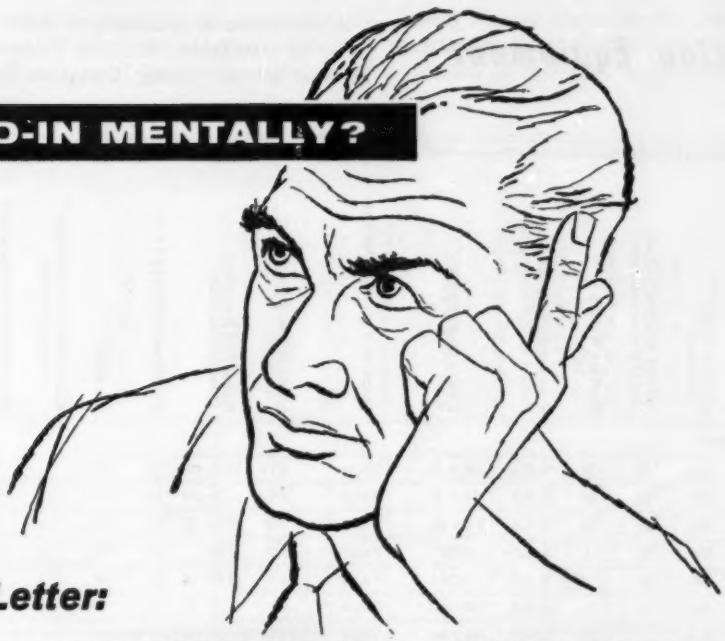
Tearing, crawling and a lessening of bond may develop with an increase in the thickness of the enamel layer. Even without these happening, an increase in enamel thickness produces a less durable article—one less able to withstand abuse in handling during installation and use. Coatings in the range of 0.002 to 0.003-in. appear to be satisfactory.

Present knowledge indicates that Type 2 requires enamels which do not fire over approximately 900 F. When heated over 900 F, there is a possibility of weakening of the bond of the metallic coating to the steel. This does not occur with Type 1 aluminized steel. Most of the presently available proprietary enamels fire above 900 F. Because of this, Type 1 is currently recommended for enameling. Generally speaking, other than the foregoing, no significant difference in the enamelability of the two types has been established under present practices.

Advantages: Certain demonstrable merits of aluminum-coated steel sheets as a base for low-firing enamels are evident. In addition to desirable properties such as rust resistance which may be had in common with aluminum, aluminized steel has remarkable resistance to distortion due to its steel core, which offers stability when heated (less sag) and cooled (very low warpage even with one-side enameling), stiffness as a handling aid, and resistance to mechanical damage. Furthermore, it offers the advantage of low bulk because lighter gage metal may be used with less auxiliary support in the fabrication of most articles. One-side enameling and lighter gages of metal may not only contribute to the quality of an item but certainly they will provide the possibility of lower costs. Less enamel, less expensive metal, easier pretreatment, less bracing, and ability to be field cut also will contribute to lower costs.

From a paper entitled "Enameling of Aluminum Coated Steel" presented at the 18th Annual Shop Practice Forum of the Porcelain Enamel Institute at the University of Illinois, Urbana, Ill., November, 1956.

BOXED-IN MENTALLY?



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Dictation Equipment

A correction is necessary to *Table 3—Characteristics of Available Dictation Equipment* on pages 96 and 97 of "Using Dictation Equipment" by

	General Information							Recording Medium Characteristics								
Manufacturer	Portability	Machine Type	Machine Cost (dollars)	Service Contract Cost (dollars/year/machine)	Machine Weight (lb)	Approximate Dimensions Width, Depth, Height (in.)	Power Requirement	Shape of Recording Medium	Initial Cost (dollars)	Recording Duration (minutes/medium)	Permanent Storage Cost	Mailability	Susceptibility to Damage During Handling	Susceptibility to Erasure During Handling	Susceptibility to Breakage During Dictation	Ease of Storage	Cross Talk, Surface Noise
Magnetic Machines																	
1	SP	C	350	22	25	15,15,8	110 v ac	Tape	2.75	15 to 120	H	PO	L	L	L	PO	N
2	SP	C	425	30	22	14,16,7	110 v ac	Tape	2.75	15 to 120	H	PO	L	L	L	PO	N
3	SP	C	200	25	12	12,10,4	110 v ac	Tape	2.75	15 to 30	H	PO	L	L	L	PO	N
4	P	C	280	N	8	8, 4,2	SCB	Tape	11.50	60	H	PO	L	L	L	PO	N
5	P	C	300	25	8	7, 4,2	SCB	Tape	9	30 to 60	H	F	L	L	L	PO	N
2	SP	C	300	—	11	12,10,3	110 v ac	Tape	2	15 to 60	H	PO	L	L	L	PO	N
6	Installation $35.00 Rental $12.50 per mo.				30	15,16,6	110 v ac	Tape	Will handle twenty messages each 28 seconds in duration.								
7	SP	DR DT C	381 375 420	25	18	11,11,6	110 v ac	Belt	0.70	15	H	E	L	H	L	F	L
8	SP	C	350	25	15	10, 6,9	110 v ac	Belt	0.80	11	H	E	L	H	L	F	L
7	SP	DR DT C	365 380 460	23	28	12, 7,12	110 v ac	Wire	20	15 to 60	H	PO	L	L	H	PO	N
9	SP	C	325	30	19	18,11,9	110 v ac	Wire	6	15 to 60	H	PO	L	L	H	PO	N
10	SP	C	250	36	28	10, 6,12	110 v ac	Wire	6	60	H	PO	L	L	H	PO	N
11	P	C	300	N	2	4, 7,2	SCB 110 v ac 6-12 v dc	Wire	6 to 33	15 to 300	H	PO	L	L	H	PO	N
12	SP	C	320	20	16	15,11,6	110 v ac	Disk	2.50	10	H	G	L	H	L	F	L
13	SP	C	220	30	12	10, 9,6	110 v ac	Disk	1.00	10	H	E	M	H	L	F	L
Embossing Machines																	
5	SP	DR DT C	360 360 450	22	13	13,10,5	110 v ac	Belt	0.04 0.08	15 or 30	L	G	H	L	L	G	M
14	SP	C	400 to 800	—	8 to 12	10, 4,9	SCB 110 v ac	Belt	0.17 to 0.25	90 to 240	L	E	H	L	L	G	M
15	SP	DR DT C	360	25	12	12,10,3	110 v ac	Disk	0.10	30	L	G	H	L	L	G	H
16	SP	DR DT C	375 365 425	25	17	9,12,7	110 v ac	Disk	0.025 0.05 0.09	8 15 30	L	G	H	L	L	G	H
16	SP	C	275	—	6	6,10,3	110 v ac	Disk	—	15	L	G	H	L	L	G	H
17	SP	DR DT	365 365	25	15	10,10,7	110 v ac	Disk	0.06 0.09 0.14	20 30 60	L	G	H	L	L	G	M
17	SP	C	425	25	15	10,10,7	110 v ac	Disk	0.06 0.09 0.14	20 30 60	L	G	H	L	L	G	M

Code No.	Trade Name	Company Name	Address
1	Memo-Tape	Technical Associates Inc.	140 W. Providencia Ave. Burbank, Calif.
2	Scribe Scribbler	Permoflux Scribe	2835 N. Kedzie Ave., Chicago 18, Ill.
3	Stenorette	DeJur-Amsco Corp.	Long Island City, N. Y.
4	Midgetape	Mohawk Business Machines Corp.	944 Halsey St., Brooklyn 33, N. Y.
5	Dictaphone, Dictet	Dictaphone Corp.	420 Lexington Ave., New York 17, N. Y.
6	Pacific Telephone	Bell Telephone System	
7	Pierce	Pierce Dictation Systems Corp.	5900, Northwest Highway, Chicago 31, Ill.
8	Comptometer	Felt and Tarrant Mfg. Co.	1735 N. Paulina, Chicago 22, Ill.
9	Steno	Crescent Industries Inc.	5900 Touhy Ave., Chicago 31, Ill.
10	Dictascriber	The Magnetic Corp. of America	Chicago 22, Ill.
11	Minifon	Geiss-America	Chicago 45, Ill.

A. N. Baxter which appeared in the December 13, 1956, issue of MACHINE DESIGN. The table was incorrect in that certain of the lines on the right-hand side of the table did not line up with corresponding lines on the left-hand page. A corrected version of the table is reproduced here.

Dictation Characteristics												Transcription Characteristics							
Adequacy of Microphone Controls	Play Back Fidelity	Physical Shock Sensitivity	Susceptibility to Accidentally Not Dictating	Recording Level Indicator	In Recording Position Indicator	End of Dictation Indicator	Ease of Record Review	Indexing System	Performance as Conference Recorder	Speed of Total Erasure	Telephone Attachment	Ease of Starting and Stopping	Ease of Locating Errors	Ease of Back Spacing	Ease of Refinding Position on Medium	Earpiece Quality	Speed Control	Tone Control	Volume Control
E	E	L	L	N	E	N	F	E	E	H	Y	G	E	G	E	F	N	Y	Y
E	E	L	M	N	G	N	F	PO	E	H	Y	G	PO	G	PO	G	N	Y	Y
F	G	L	M	N	G	N	PO	F	G	H	Y	F	PO	E	PO	E	N	Y	Y
N	PO	L	M	N	N	N	PO	PO	F	L	Y	PO	PO	PO	PO	F	N	N	Y
N	F	L	M	N	PO	N	PO	PO	PO	L	N	PO	PO	G	PO	F	N	N	Y
—	—	L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	G	L	This is automatic telephone answering unit.									Units available from which transcriptions can be made.							
G	G	L	M	N	PO	Y	G	G	G	H	Y	G	G	E	G	G	Y	Y	Y
G	G	M	M	N	F	Y	G	F	G	H	Y	G	F	G	F	G	N	Y	Y
F	G	L	M	N	N	N	F	E	G	H	Y	G	PO	F	PO	F	N	N	Y
PO	G	L	H	Y	N	N	PO	G	G	H	Y	G	G	E	G	G	N	N	Y
PO	G	L	H	Y	N	Y	F	G	G	H	Y	G	G	G	G	G	N	Y	Y
N	F	L	M	N	PO	Y	F	PO	F	H	Y	F	PO	F	PO	G	N	N	Y
P	G	H	M	N	PO	Y	F	PO	PO	H	Y	F	F	F	F	F	N	N	Y
F	G	M	M	N	N	N	G	F	F	H	Y	G	F	PO	PO	F	N	N	Y
G	G	M	L	Y	Y	Y	G	G	G	N	Y	G	G	G	G	G	Y	Y	Y
F	F	M	M	Y	N	N	G	F	G	N	Y	F	F	F	F	F	Y	Y	Y
F	PO	H	H	N	PO	Y	F	F	PO	N	Y	G	PO	G	PO	F	Y	Y	Y
G	F	M	L	Y	Y	Y	G	G	F	N	Y	G	E	G	G	F	Y	Y	Y
F	F	H	H	N	PO	Y	G	F	F	N	N	F	F	N	F	F	N	N	Y
G	F	M	M	Y	Y	Y	G	G	F	N	Y	G	F	G	PO	F	Y	Y	Y
G	F	M	M	Y	Y	Y	G	G	F	N	Y	G	F	G	PO	F	N	Y	Y

Code No.	Trade Name	Company Name	Address
12	Rex	American Dictating Co.	65 Madison Ave., New York 16, N. Y.
13	Voice-Master	Magnetic Recording Industries	30 Broad St., New York 4, N. Y.
14	Walkie Recordall	Miles Reproducer Co. Inc.	812 Broadway, New York 3, N. Y.
15	Tele-Voicewriter Ediphone Vice President	Thomas A. Edison Inc.	West Orange, N. J.
16	Sound Scriber	The SoundScriber Corp.	145 Munson, New Haven, Conn.
17	Audograph	Gray Mfg. Co.	16 Arbor St., Hartford 1, Conn.

Key To Code Letters

C = Combination Unit
DR = Dictation Receiver
DT = Dictation Transcriber
E = Excellent
F = Fair
G = Good
H = High
L = Low
M = Medium
N = No or None
P = Portable
PO = Poor
S = Stationary
SP = Semiportable
SCB = Self-Contained Batteries
Y = Yes

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Motor Operated Valves

Series of motor operated shut-off valves for high pressure control of liquid oxygen, oxidizers, jet fuels, hydraulic fluids and air is described in data sheet 23. Design features are covered. 2 pages. Hydromatics Inc.

Circle 601 on page 19

Gas Engines

Improved model G-825 Superior gas engines, offered in six and eight-cylinder four-cycle models, and designed to operate at 900 rpm and develop from 200 to 630 bhp, are detailed in illustrated bulletin 104. Design features are presented. White Motor Co., White Diesel Engine Div.

Circle 602 on page 19

Control Centers

Construction and design features of 7-in. high motor control centers are detailed in catalog 2-2000. Wide variety of sizes, heights, widths and depths is offered. Up to 20 size 1 starters can be mounted in a single standard height enclosure. 28 pages. Federal Pacific Electric Co.

Circle 603 on page 19

Industrial Lighting

Sections on safety and visibility factors; plant lighting standards; uses of fluorescent, incandescent and mercury vapor lamps; lighting of other areas; maintenance; and fixtures are contained in booklet "Prescribed Lighting Protects the Eyes of Industry." 28 pages. Sylvania Electric Products Inc.

Circle 604 on page 19

Milling Cutters

RC milling cutters which use Throway carbide inserts are described and illustrated in catalog 11156. Features of the holder and prices and specifications for the square and triangular inserts are included. 4 pages. Newcomer Products, Inc.

Circle 605 on page 19

Transformer Control Synchros

Three-minute size 23 synchros, designed for airborne applications requiring accuracy with minimum bulk and weight are described in illustrated bulletin 409. They have preloaded bearings, high torque and high temperature insulations. Specifications are given. 4 pages. Norden-Ketay Corp.

Circle 606 on page 19

Machine Lubrication

Automatic and semiautomatic centralized metered lubrication systems for a wide range of small machines are described and illustrated in bulletin 4C. Selection factors, distribution systems, installation details and descriptions of cyclic and "one-shot" lubricators are included. 24 pages. Bijur Lubricating Corp.

Circle 607 on page 19

Pipe, Tubing & Fittings

Condensed data on mechanical and physical properties, creep strength, hot and cold bending, welding, heat treatment and working pressure are content of technical data card 152-A on Croloy steel pipe, tubing and welding fittings. Sizes range up to 9⅝ in. OD. 4 pages. Babcock & Wilcox Co., Tubular Products Div.

Circle 608 on page 19

Remote Controls

Electrical remote positioning controls for pushbutton and automatic operations are described in illustrated bulletin J-100. Shaft mounted control gearmotor for valves and variable speed drives provides automatic flow, speed, proportion and tension control. 8 pages. Jordan Co.

Circle 609 on page 19

Gray Iron Castings

"Engineering and Purchasing Requirements for Gray Iron Castings" is title of folder of interest to designers, engineers and purchasing agents. It states what information should be supplied with an order or request for quotation for castings. 8 pages. Gray Iron Founders' Society, Inc.

Circle 610 on page 19

Epoxy Resin Adhesives

Engineering data on high strength epoxy resin adhesives for metal-to-metal bonding and honeycomb sandwich construction are found in technical bulletin. 11 pages. Minnesota Mining & Mfg. Co., Adhesives & Coatings Div.

Circle 611 on page 19

Fluid Drives

Advantages and applications of adjustable speed type VS Class 2 Gyrol fluid drives are discussed in illustrated bulletin A-119. Size range is from 7½ to 800 hp. Selection tables cover entire line and installation type drawings give basic dimensions of each unit. 8 pages. American Blower Corp.

Circle 612 on page 19

Stainless Steel Fasteners

Condensed stock list of stainless steel fasteners illustrates 37 different basic fastening devices. Included are screws, bolts, nuts, washers, rivets, pins and AN specification fasteners. Specs for each are given. 8 pages. Allmetal Screw Products Co.

Circle 613 on page 19

High Temperature Insulation

Important points to consider in selecting high temperature insulation are brought out in illustrated folder. Comparative data on 14 types of fibrous insulations are included. Rating highest are silica and aluminum silicate fibers for operating temperature range of 2000°F. 6 pages. H. I. Thompson Fiber Glass Co.

Circle 614 on page 19

Flexible Couplings

Custom designed to meet any requirement, Lord flexible couplings are available in wide range of sizes with torque capacities from 1/80 to 3500 hp. These bonded rubber constructed couplings are descriptively covered in bulletin 203. 4 pages. Lord Mfg. Co.

Circle 615 on page 19

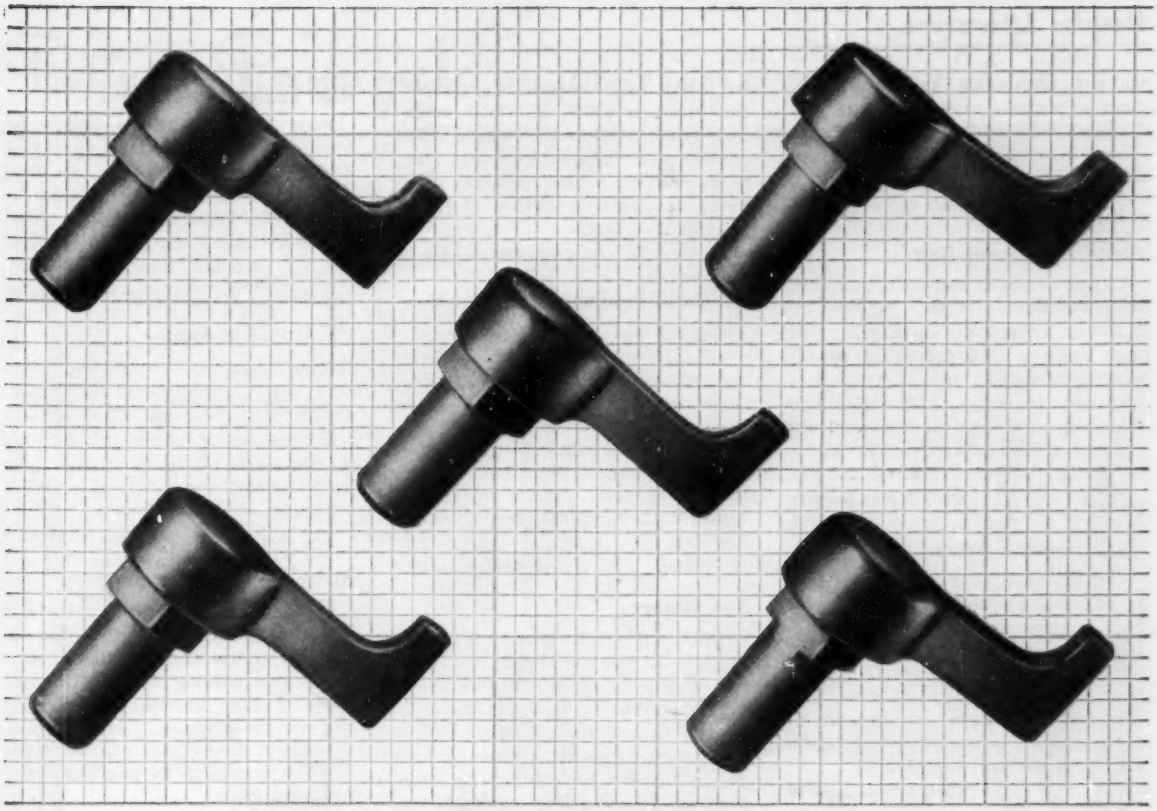
Friction Materials

Asbestos brake blocks, linings and clutch facings make up some of the industrial friction materials described in booklet FM-35-A. Most of the design data are arranged in chart form for easy reference. 16 pages. Johns-Manville.

Circle 616 on page 19

Power Lubrication

"Power Lubrication" is title of catalog 811 which gives latest details on new, power-operated, cen-



Cam Segment—weighs less than an ounce, measures less than ½ inch.

Investment-Casting improves part ... eliminates hours of machining

HAYNES' investment-casting process made it possible to mass-produce a small intricately-shaped part in a hard, abrasion-resistant alloy. The part, a cam segment, is less than one-half inch long, and weighs only a fraction of an ounce. It is cast to size. Only one simple threading operation is required to prepare it for operation.

The cam segment is used in a control instrument and rides against a valve shaft under pressures up to 35 lb. per sq. inch. At one time it was cast from a relatively soft metal and machined to final dimensions. The machining time for each cam was several hours—an expensive operation. The performance of the part was unsatisfactory because the metal used was selected for ease of machining—and could not stand up under the abrasive conditions.

The investment-cast segments are now made of type 410 stainless steel. They have been used for over one million operations and still show no signs of wear.

The freedom to select alloys for performance, regardless of how difficult they may be to machine, is one of the big advantages of HAYNES' investment-casting method. Intricate shapes in hard metals can be cast close to size, eliminating many machining operations. For full details on the process, write to our general sales office in Kokomo, Indiana, or any of the district sales offices listed below.

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HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

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"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

tralized lubrication systems. Functions of manual as well as both mechanical and electric automatic controls are covered. Lincoln Engineering Co.

Circle 617 on page 19

Photo Processing Unit

In one compact, self-contained unit, the JAco Photoprocessor provides all facilities for uniform developing, fixing, washing and drying of photographic films and plates. It can also be used in x-ray diffraction and metallographic laboratories, and for processing photomicrographs. Catalog P6-56. 4 pages. Jarrell-Ash Co.

Circle 618 on page 19

Gear Shaper Cutters

"Know Your Gear Shaper Cutters" is title of revised booklet which describes these tools for cutting cluster, shoulder and herringbone gears. Changes in the shaper cutter as they are sharpened back and how this affects generating action and life of cutter are comprehensively discussed. 20 pages. Illinois Tool Works.

Circle 619 on page 19

Ball Modification

Machining methods and materials used for modifying balls are described in bulletin FB-1. Balls can be used for valves, gaging, indicator points and burnishing tools. 2 pages. Industrial Tectonics, Inc.

Circle 620 on page 19

Metering Pumps

Catalog 602 provides specifications and other data on model U and K mechanical and hydraulic drive metering and proportioning pumps, the Hills-McCannameter for precision pumping as low as 11 cc per minute and model 4411 chemical pump. 8 pages. Hills-McCanna Co.

Circle 621 on page 19

Special Fasteners

The Flo-Form process of designing special parts, determining the most suitable alloy, then manufacturing the finished fastener is subject of Flo-Form brochure 613. Some of the many special fastenings being produced in small quantity are illustrated. 24 pages. H. M. Harper Co.

Circle 622 on page 19

High Temperature Alloy

Wrought, nickel-base, aluminum and titanium-bearing Hastelloy alloy R-235 is a precipitation-hardening alloy with outstanding properties through 1750° F. Good oxidation resistance, low strategic alloy content and resistance to overaging in service are other features. Form 30052 describes properties. 12 pages. Haynes Stellite Co.

Circle 623 on page 19

Hydraulic Equipment

Dimensional data sheets on hydraulic reservoirs and pumping unit accessories are provided in bound folder entitled "Engineered Hydraulic Equipment" along with appropriate engineering data. Oil level sight gages, breather caps, filter breather assemblies and clarifier units are covered. 12 pages. Century Hydraulics, Inc.

Circle 624 on page 19

Fan Motors

Advanced construction features of type KCP permanent-split capacitor fan motors for room aid conditioners are illustrated in bulletin GEA-6533. Motors range from 35 mhp to 1/6 hp. Design Engineer's Corner in book points motors versatility, low temperature rise and high power factor. 8 pages. General Electric Co.

Circle 625 on page 19

Ball Bearings

Wide range application of Freeway semiprecision ball bearings is depicted in bulletin S-61. Data cover standard and special bearings, sizes, and installation. Nylon bearings for low-rpm uses are also included. 4 pages. Freeway Washer & Stamping Co.

Circle 626 on page 19

Temperature Controls

Two types of cigarette-size midget Thermoswitch units and variety of tiny rectangular and circular thermostatic units are described in brochure MC-132. Controls are designed for airborne equipment, guided missiles and related applications. 6 pages. Fenwal Inc.

Circle 627 on page 19

Centrifugal Pump

The magnetic Dynapump fractional horsepower centrifugal pump requires no drive shaft and no shaft seal. It can be used for water, solvents, refrigerants, corrosive fluids, liquid chemicals, hazardous fluids and food products. Performance data and specifications are given in form P-354. 4 pages. Fostoria Pressed Steel Corp.

Circle 628 on page 19

High Temperature Alloys

Four Handy Hi-Temp alloys for brazing stainless steel and variety of heat-resistant metals are specified with recommended applications in bulletin 22. These alloys have nickel contents ranging from 72.5 to 93.25 per cent. 4 pages. Handy & Harman.

Circle 629 on page 19

Air Motors & Pumps

Gast rotary air motors, compressors and vacuum pumps are subject of descriptive bulletin 555-A. A rotor and four sliding vanes are the only moving parts in the Gast rotary design. Latest price list is included. 8 pages. Gast Mfg. Corp.

Circle 630 on page 19

Automation Gaging Systems

Electric, air-electric, electronic and air-electronic gaging systems for automatic control are explained in comprehensive catalog 56 AM. Components of each system are described as on-the-machine, after-the-machine and continuous process types of control gaging. 26 pages. Federal Products Corp.

Circle 631 on page 19

Plastic Rivets

Fastex self-expanding Plasti-Rivets described in form AF-7 are suited for fastening any material from paperboard to metal. They are molded from nylon, acetate, butyrate, polystyrene, polyethylene and other thermoplastics. 4 pages. Illinois Tool Works, Fastex Div.

Circle 632 on page 19

Relief Valves

Schematic drawings of both guided piston and differential piston hydraulic dual relief valves, plus capacity ranges, pipe sizes, dimensions and typical uses are featured in catalog sheets 1.61 and 1.60a. Fluid Controls, Inc.

Circle 633 on page 19

Window Units

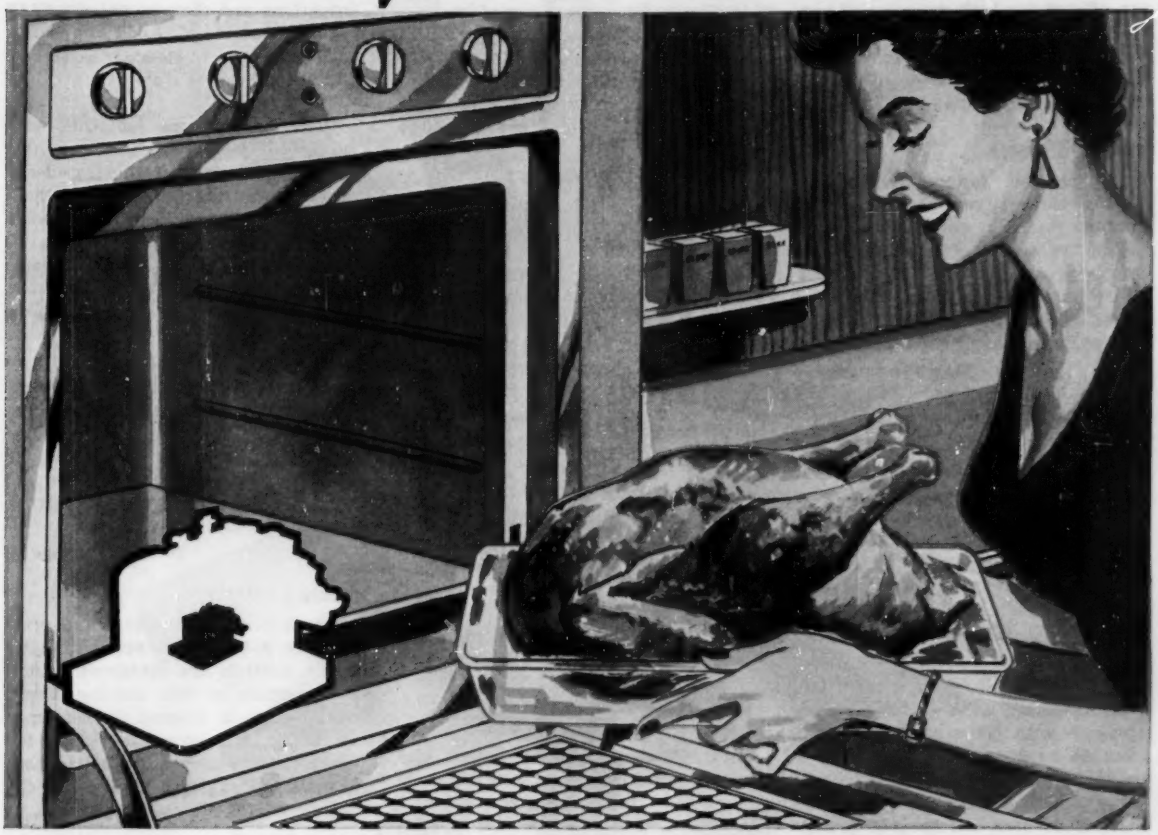
One-piece press-fit circular window units for observing internal operations, indicating flow, or showing internal liquid level in wide range of machines are described in bulletin 4D. 4 pages. Bijur Lubricating Corp.

Circle 634 on page 19

Shoe Brake Assemblies

Technical bulletin BD-12 describes operation, construction and performance of Fawick (Girling) two-lead-

Potter & Brumfield *engineering is in this picture*



Which P&B relay would you specify to CONTROL AN ELECTRONIC OVEN?

PR Series

MS Series

MR Series

New electronic ovens—the kind which cook an 18-pound turkey in an hour and a half, a large beef roast in 30 minutes, or bake potatoes in 4 minutes—require heavy duty, fast-acting relays designed for high voltage switching. Long, trouble-free service is essential and U/L approval is a must.

The relay specified by one top manufacturer to fill this bill is P&B's PR 11, specially adapted to our customer's specifications. P&B engineers are old hands at adapting basic relay types to highly specialized uses. Twenty-five busy years of relay designing, engineering and manufacturing at P&B have built an unrivaled backlog of information and skill which is yours to command.

ENGINEERING DATA

SERIES: PR Heavy Duty.

CONTACTS: Max. DPDT. 5/16" dia. silver, 13 amps. at 115 V., 60 cycle, non-inductive. 6.5 amps. at 230 V. 60 cycle, non-inductive.

VOLTAGE RANGE: 6 to 110 V. DC. 6 to 230 V. AC.

COIL RESISTANCE: 63800 ohm max. DC.

TEMPERATURE RANGE: DC, -45° to 85° C. AC, -45° to 55° C.

PULL-IN: DC, 75% nominal. AC, 78% nominal.

TERMINALS: Heavy duty screw type. Adaptable for printed circuits or plug-in.

BASE: Molded phenolic or metal.

MOUNTING: (2) 3/16" dia. holes on 1⅞" centers.

DIMENSIONS: 2½" W. x 3⅜" L. x 2½" H.

P&B RELAYS AVAILABLE AT MORE THAN 500 DISTRIBUTORS IN ALL PRINCIPAL CITIES

Potter & Brumfield, inc. PRINCETON, INDIANA

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

ing-shoe brake assemblies. Brakes are offered for both driving and non-driving axles in all types of commercial vehicles. 6 pages. Fawick Corp., Fawick Brake Div.

Circle 635 on page 19

Rotary Blowers

Applications for which Miehle-Dexter blowers can provide air or gas are shown in bulletin 255. Specs for 50 to 4000-cfm units with discharge pressures to 14 psig, vacuum to 15 in. of mercury are given. 6 pages. Dexter Folder Co., Miehle-Dexter Supercharger Div.

Circle 636 on page 19

Air-Operated Clutches

Line of Flex-Disc and Gear Tooth industrial clutches adapted for air operation are subject of illustrated bulletin 5011. Ten sizes in each type are available for applications requiring 1600 to 30,000 lb-in. working torque. 2 pages. Industrial Clutch Corp.

Circle 637 on page 19

Circuit Breakers

Standardized AB-I enclosed circuit breakers with 600-v ratings ranging from 15 to 600 amp are covered in bulletin 1-155. Featured are the versatile plug-in StABreakers for use in StAB-Inclosures. All breaker ratings within the same frame size are interchangeable. 20 pages. Federal Pacific Electric Co.

Circle 638 on page 19

Tantalum Capacitors

Intended primarily for low voltage transistor circuits, type STA hermetically sealed solid tantalum capacitors contain no liquid electrolyte. Bulletin 6.110 lists 24 ratings from 1 mfd at 35 working volts dc to 350 mfd at 2 working volts. Fansteel Metallurgical Corp., Rectifier-Capacitor Div.

Circle 639 on page 19

Sprag Clutches

Wide range of actual uses for sprag clutches in overrunning, indexing and backstopping applications is described and illustrated in catalog 104-C. Data are devoted to installation, maintenance and mounting. Specifications are given. 26 pages. Formsprag Co.

Circle 640 on page 19

Sprayed-on Heat Elements

Difficult heating problems due to odd contour shapes, space and/or weight limitations are solved by use of Electrofilm sprayed-on film type heating elements, according to series of illustrated folders. Heaters are engineered to individual design. Electrofilm, Inc.

Circle 641 on page 19

Fluid Flow Transmitters

Transi-Twin pneumatic and electric transmitters for Brooks rotameters are described in illustrated bulletin 170. Use can be with secondary instruments of any manufacture. Detailed application and operation data, plus schematic drawings, are included. 6 pages. Brooks Rotameter Co.

Circle 642 on page 19

Investment Castings

"Design with Austenal in Mind" is an illustrated folder which outlines the investment casting-making facilities of this company. Captions for illustrations briefly describe steps in their manufacture. 4 pages. Austenal Inc., Microcast Div.

Circle 643 on page 19

Optical Tooling

Theory, principles and practice of optical tooling, a method of measuring, positioning and aligning, are explained in illustrated booklet A-2230. Line of Brunson optical tooling instruments and accessories is described. 20 pages. Charles Bruning Co.

Circle 644 on page 19

Swivel Joints

Plane and self-aligning aircraft type swivel joints for hydraulic, pneumatic, oxygen, fuel, gas and liquid service are subject of catalog 269-A. Both types provide 360-degree rotation, and latter type has 15-degree side flexibility. Specifications are given. 12 pages. Barco Mfg. Co.

Circle 645 on page 19

Magnetic Materials

Properties and applications of various materials used in permanent magnets and tape wound, powder and cut cores are presented in bulletin GC-106A. Available sizes are listed. 12 pages. Arnold Engineering Co.

Circle 646 on page 19

Air Cylinders

Valve-in-head air cylinders of single and double solenoid, air operated, hand valve-double actuation, hand valve-spring return, double air pilot and air pilot-spring return types are described in two 4-page folders. Specifications and dimensional drawings are included. A. K. Allen Co.

Circle 647 on page 19

Gears

Brief descriptions of the wide range of gears produced by this company are given in illustrated circular C-102. Included are spur, helical, bevel, miter, internal and worm gears; worms; splined shafts; racks and speed reducers. 4 pages. Adams Co.

Circle 648 on page 19

Grommet V-Belts

Construction features of Texrope grommet V-belts are given in illustrated bulletin 20B6497C. It states they have one-tenth the shrinkage, one-third the stretch, run cooler and grip better than ordinary belt. 4 pages. Allis-Chalmers Mfg. Co.

Circle 649 on page 19

Motor Controls

Operational, dimensional and price data on A-B manual and automatic motor controls are contained in seventh edition of this catalog. Easy-to-use guide is indexed for reference and aids in selection of units for every type of service, including hazardous. 132 pages. Allen-Bradley Co.

Circle 650 on page 19

Magnesium Extrusions

Information on manufacturing limits of a new 13,200-ton extrusion press as compared to limits formerly available is found in booklet "Start Now Designing Big Magnesium Extrusions." 4 pages. Dow Chemical Co.

Circle 651 on page 19

Electrical Laminate

Properties of Grade TS polyester glass-mat laminate which adapt it for use in electrical equipment and components are covered by illustrated data sheet. Material is available in thicknesses of 1/16 to 1¼ in. and in sheet sizes of 24 x 36 in. and 36 x 72 in. Glastic Corp. 4321 Glenridge Rd., Cleveland 21, O.

Fabricated Metal Products

Solutions for a variety of electrical and electronic manufacturing problems are suggested in fabricated metal products brochure. Custom-produced slip-ring and microwave assemblies, button welding and crossbar contacts, and stamped laminated contacts are described and illustrated. D. E. Makepeace Co., Pine & Dunham Sts., Attleboro, Mass.

The California Division of Lockheed has a special problem. It doesn't limit itself to a few types of planes. It develops virtually all types—cargo and commercial transports, extremely high-speed fighters, radar search planes, jet trainers, patrol bombers and others still classified. And it takes a constant flow of new design ideas to feed this ever-expanding program.

Do you have new ideas? They'll get attention at Lockheed. Your future relationship with us is certainly worth exploring. Perhaps the most convenient method for you to take in contacting us is to write, E. W. Des Lauriers, Manager, Professional Recruiting, or send in the brief résumé form below.

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Lockheed Aircraft Corporation
Burbank, California

Dear Sir: Please send me your brochure detailing life and work at Lockheed

Name

If you are an engineer, please state your field of engineering

Home street address

City and State Home phone

Circle 478 on page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Self-Locking Fasteners

vibration-proof units also prevent leakage

Vibration-resistant screws for aircraft and commercial uses have insert of various materials for low, medium or high temperatures. Locking device is effective in pre-

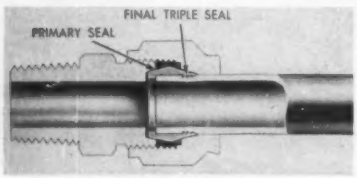
venting leakage at well above normal aircraft and commercial fluid pressures. Screws are available in all lengths and in diameters from No. 0-80 to ½-in. **Long-Lok Corp.**, 8404 Melrose Ave., Los Angeles 46, Calif.

Circle 652 on page 19

Tube Fitting

withstands high pressures

Flareless tube fitting provides foolproof, butt-tight joint for full range of pressure conditions. Available in steel or stainless steel



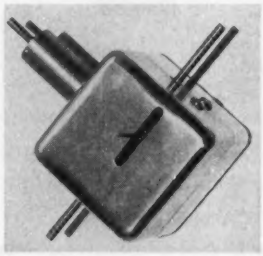
in sizes from ⅛ to 1½ in., seal fitting consists of body, nut and alloy-steel sleeve. Fitting withstands high pressures, hydraulic surge, vibration and other severe operating conditions, and no flaring or threading of tubing is required in making assemblies. **Imperial Brass Mfg. Co.**, 1200 W. Harrison St., Chicago 7, Ill.

Circle 653 on page 19

Mechanical Integrator

requires small force to change speeds

Floating ring integrator, consisting basically of a disk, drum and ring, requires a minute force (less than 0.5 gram) to position the ring and control the output-drum shaft speed relative to the input-disk shaft speed. Negligible force is required to maintain the ring position under varying speed and load conditions. Integrator is suitable for a wide range of applications from chart integrators and servo mechanisms



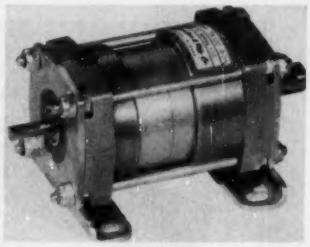
to variable speed drives and linear to rotary motion converters. Case size is 3 x 3 x 3 in.; shafts are 0.187-in. diam. **Optimum Engineering Co.**, 2017 Willow St., Grand Prairie, Texas.

Circle 654 on page 19

Speed Reducer

small unit provides ratios to 1:40,188

Planetary gear box is for use in applications requiring a small-size speed reducer for intermittent service. Unit is available in ratios from 1:4.14 to 1:40,188. Output torque varies from 100 lb-in. at the



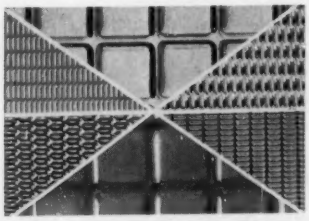
low ratios to 250 lb-in. at high ratios. Reducer has ball bearings on input shaft and oilite bearings on output and planets. Hardened gears provide long, trouble-free service. Reducer is available with foot or flange mountings. **Arizona Gear & Mfg. Co.**, 3544 E. Fort Lowell Rd., Tucson, Ariz.

Circle 655 on page 19

Embossed Metals

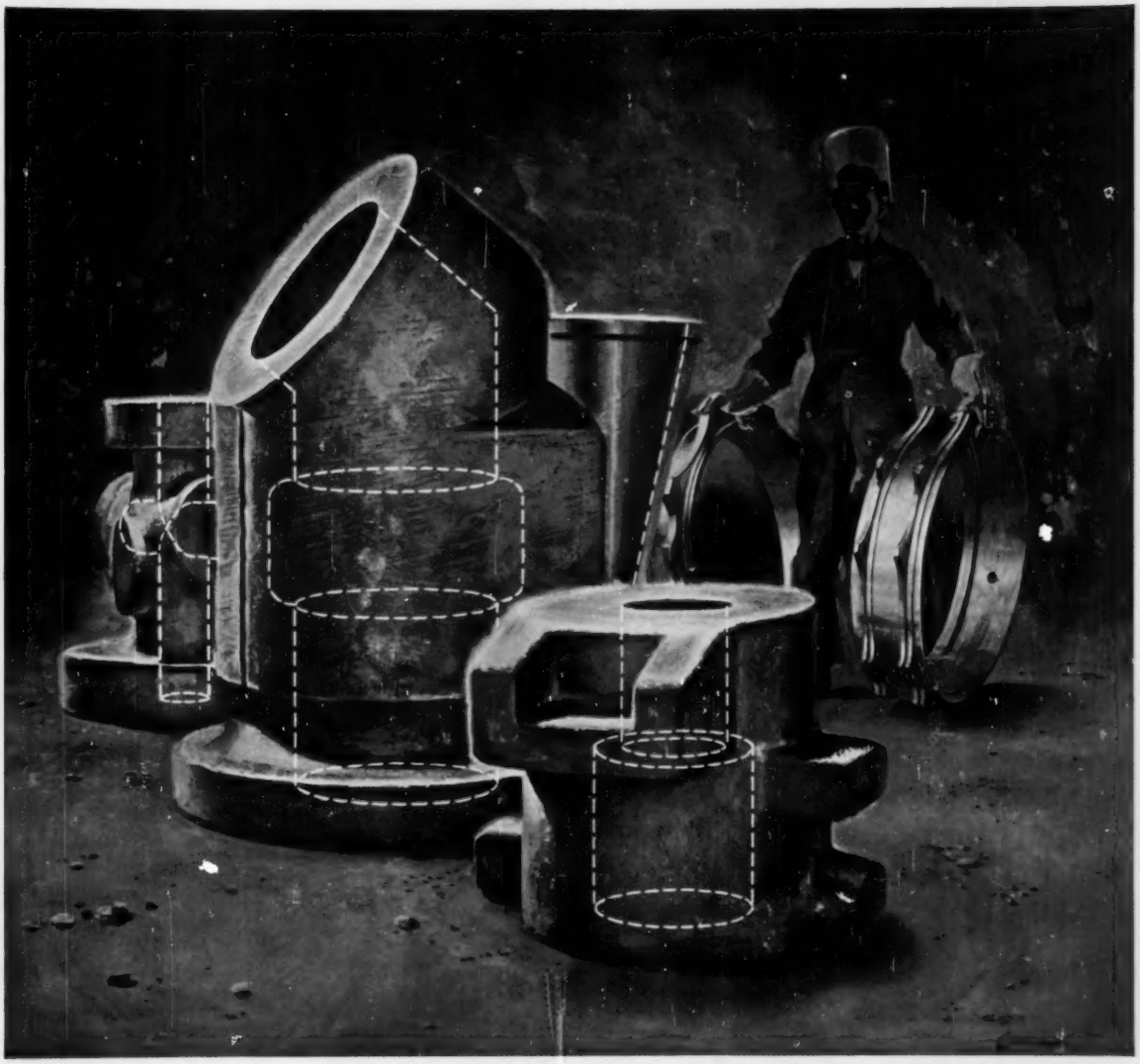
in six new decorative finishes

Six new patterns are available in nonferrous or ferrous metals in gages from 0.012 to 0.040-in. Wicker Weave 650 is a pattern of embossed interlocking links measur-



ing three per inch. Maximum width of stock is 16⅛ in. Chain Mail 652 is a pattern of debossed grooves; widths to 16⅛ in. Block 700 and Grid 702 are bold patterns composed of ¾-in. squares. Block is embossed and Grid is de-

Circle 479 on page 19→



Cameron

IRON WORKS, Inc.

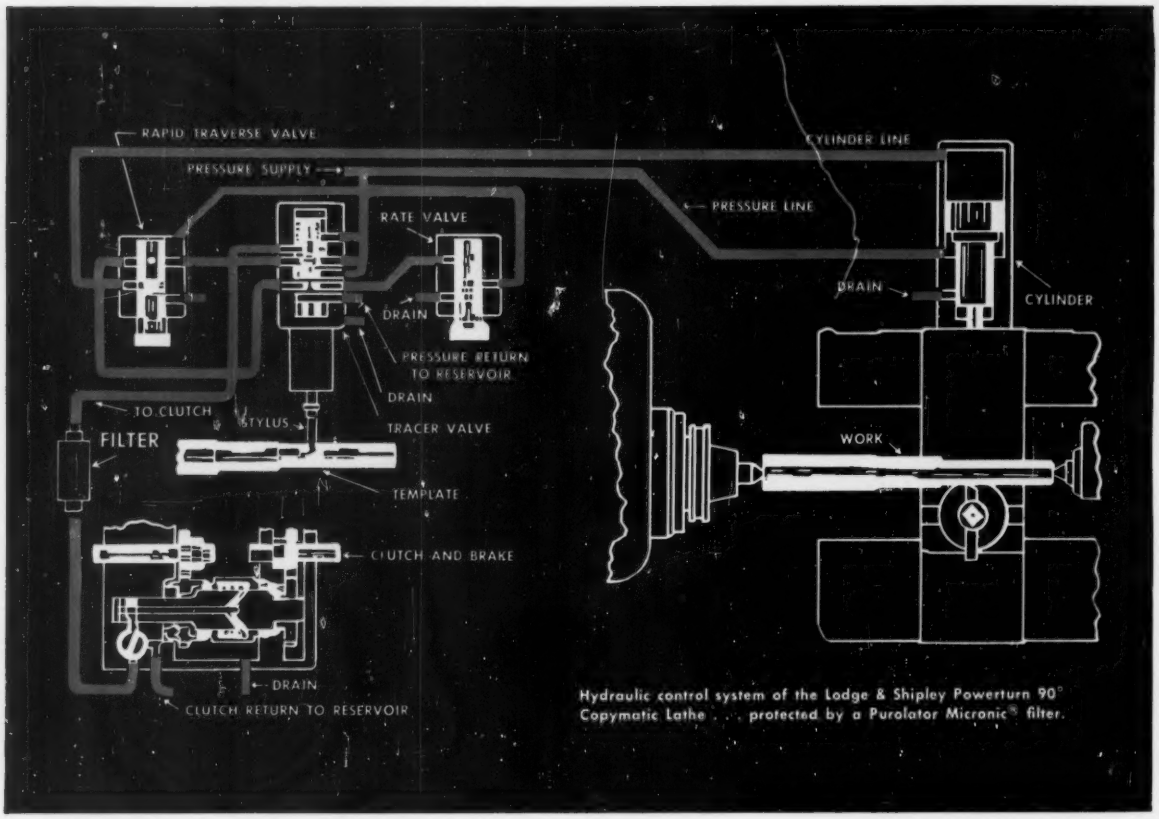
SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

Cameron Split-Die Forgings

are different – they are made possible by something new in the metal-working industries. Intricate ferrous forgings with internal as well as external contours are being mass-produced. These near-final shapes with greatly improved grain structures are creating a new concept in the design and use of forgings.

Cameron's split-die forgings offer a variety of shapes and sizes (200 lbs. to 5,000 lbs.) in alloys to meet the extreme demands of today. They may be supplied as forged, rough machined, or finish machined, ready to save money on final operations. It is now possible to take advantage of the many benefits offered by high grade alloy ferrous* forgings in applications never before possible. Investigate these advantages. Write or call...

* ferritic or austenitic



Hydraulic control system of the Lodge & Shipley Powerturn 90° Copymatic Lathe . . . protected by a Purolator Micronic® filter.

Designed for highly accurate control ...fully protected by Purolator Filtration

On a very successful automatic duplicating lathe, this hydraulic control system makes possible both quick, simple operation and a high degree of sensitivity and accuracy. Reliable and uninterrupted operation of a system like this is dependent upon freedom from contaminants. That's why the Lodge and Shipley Company, its manufacturer, made Purolator Micronic® filters an integral part of their hydraulic system.

Purolator engineers recommended a standard filter from their stock of over 2000 models. It more than met the system's special requirements.

The controlled porosity of Purolator's Micronic element evenly filters out contaminant particles as small as .000039 inch. And because it's made of plastic-impregnated cellulose, the Micronic element is not affected by high temperatures, water, or oil.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

Filtering information for product designers is available in our 32 page "Filtration Manual for Product Designers". Just enclose 25¢ to cover postage and handling. Address Dept. P5-18

Circle 480 on page 19

New Parts

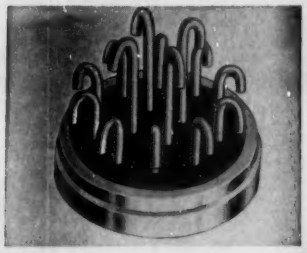
bossed; widths to 15¾ in. Baguette 800 consists of embossed baguette-diamond shapes; widths to 16-in. Roman Brick 802 resembles continuous stacks of tiny bricks, debossed and separated by a slender rib; widths to 16 in. **Croname Inc.**, CroRoto Div., Dept. 10, 3701 N. Ravenswood Ave., Chicago 13, Ill.

Circle 656 on page 19

Terminals

are available in wide range of types

Glass-to-steel terminals for application in electronic circuits have headers made with solid glass interfusion between glass and electrodes. Headers offer great resistance to vibration and mechanical and heat shock. Four different



base designs are available with 1 to 21 electrode pins mounted in each base depending on size and type. Six different electrode pin styles are available. Insulation resistance is 100,000 megohms and voltage range is 1400 to 2500 v, rms. Hot tin dipped finish is standard. **Fusite Corp.**, Dept. PB, 6000 Fernview Ave., Cincinnati 13, Ohio.

Circle 657 on page 19

Rotary Seal

has temperature range of −120 to 500 F

High-pressure seal, Series N-9000, is designed for shafts which pass through panels or housings and for rotary switches. Seal incorporates a hexagonal nut which accommodates standard panel knobs and can be tightened with an ordinary open-end wrench or pliers. Seal consists of a grooved nut molded to a silicone rubber boot. Sealing is accomplished by a gasket-rib which seats firmly against

(*Continued on Page* 162)

Circle 481 on page 19→

* Whether president, engineer, coremaker, or molder, the men at Hamilton Foundry all have one thing in common . . . they are *quality* conscious.

Specifications are hit "on the nose" however tough the problem. You get true-to-pattern accuracy . . . skin-smooth finish . . . better machinability . . . right metal specifications. You get castings that satisfy all your requirements—completely.

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AND MACHINE CO.
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HS7-1

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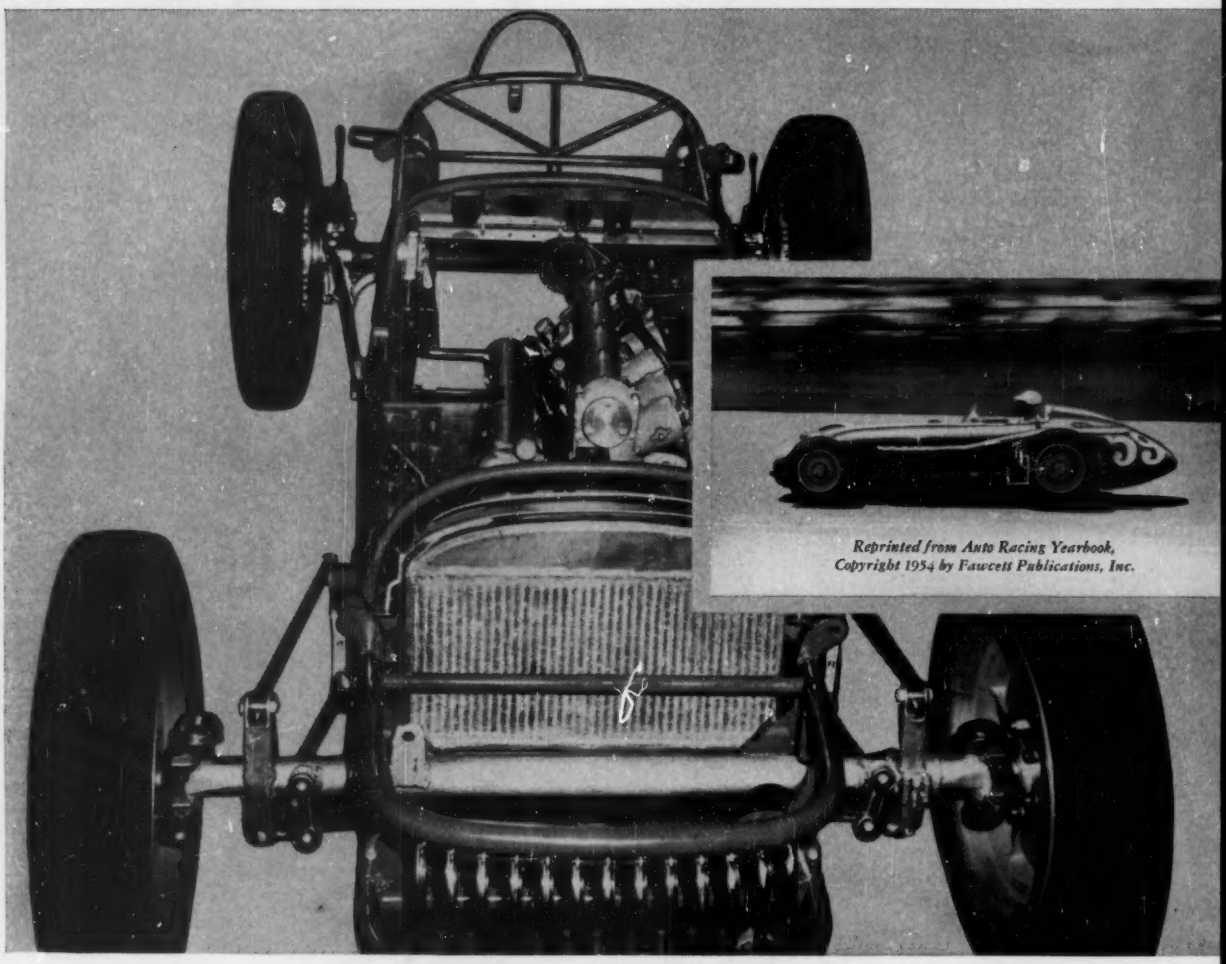
Pound for Pound, Tubular



The body frame of this high-performance racing car is fabricated from steel tubing to obtain maximum strength at reduced weight.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Construction is STRONGEST!

That's why racing-car designers and builders fabricate body frames from steel tubing. A combination of high speed and rugged endurance demands a framework that is both lightweight and strong.

They know that at any given weight, tubing is the strongest of all mechanical shapes—stronger in torsion, stronger as a beam, stronger under compressive loads.

When it comes to a choice, remember: The most economical steel mechanical tubing, dollar for dollar, is Republic ELECTRUNITE®, the *original* electric resistance welded tube. Recognized throughout industry for its exceptional quality, Republic ELECTRUNITE is available in a wide variety of forms, sizes and gages—in both carbon and stainless steels.

Though produced in great volume, every foot in every shipment of ELECTRUNITE tubing is *consistently uniform,* including wall thickness, ductility and concentricity. Surfaces are free from scratches and pit marks. Response to heat treatment is uniform. And it is easy to bend, work with . . . often eliminates costly fabricating or machining operations.

If strength, lightness, safety are requirements in your product, investigate Republic ELECTRUNITE Steel Tubing. Our engineers will help you with design problems, show you the way to greater economies and profits. Send coupon for facts.

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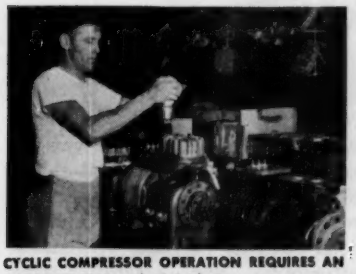
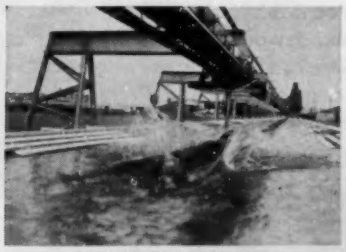
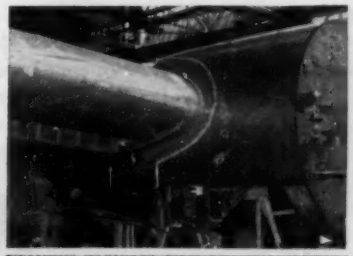


CYCLIC COMPRESSOR OPERATION REQUIRES AN ABSOLUTE SEAL at the joint between compressor cylinder and head. Republic Alloy Steel Hex Head Cap Screws are made to order for this application because they neither stretch nor lose their grip under the heating and cooling cycle of on-off operation. In fact, they more than meet tensile strength, yield point, hardness and ductility requirements. Republic makes 20,000 standard and 8,000 special types of headed and threaded products for every application. Send coupon for full information.



STRONG RESISTANCE TO CORROSION, WEAR AND ABRASION make Republic Cold Finished Stainless Steel Bars ideal for this unique application. It's a testing tank for advance-type seaplane hulls. Testing is conducted by suspending hull model from carriage which rolls on Republic Stainless Steel Bars. Besides ease of maintenance, these bars provide higher tensile and yield strength, close tolerance, and a fine surface finish, permitting smooth, accurate operation of testing device. Republic metallurgists and engineers will help you apply stainless steel to your present and future work.



TITANIUM PROVIDES STRENGTH AND WEIGHT-SAVINGS in aircraft such as the DC-7. Republic is an old hand at this high strength-to-weight business. We pioneered the use of alloy steels, then stainless steels—followed by high strength steels. Now come Republic Titanium and Titanium Alloys. Years of experience gained in helping hundreds of manufacturers design and re-design their products to get more strength with less weight are available to you. To get more information on how corrosion-resistant titanium can solve many problems, send coupon.

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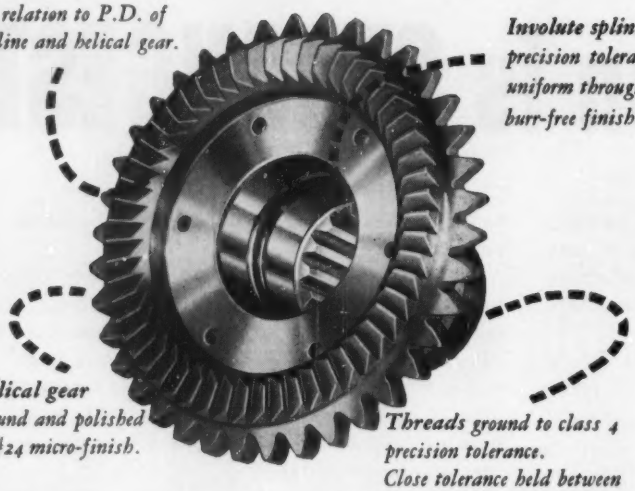
Circle 482 on page 19

Generated clutch held at close tolerance in relation to P.D. of spline and helical gear.

Involute spline, precision tolerance, uniform throughout, burr-free finish.



Helical gear ground and polished to #24 micro-finish.

Threads ground to class 4 precision tolerance. Close tolerance held between thread and P.D. of helical gear.

DON'T GAMBLE WITH GEAR PERFORMANCE

YOU know that gambling with gears can cost you money — production delays, costly rejects, failures in use. You don't want to take chances with your customers . . . they expect day-in, day-out performance from your machines. Your performance guarantee can be Perkins custom-cut gears . . . precision gears made to your exact specifications. Perkins' 52 years of gear-making know-how, extensive facilities and equipment, and rigid production controls assure uniform tolerances throughout . . . *plus* a consistent micro finish. You get perfect meshing and full capacity from every gear. Many leading manufacturers — Sikorsky, Stanley, Universal Winding, for example — rely on Perkins for top-quality gears, gears that cost less in the long run. Ask us to quote on your next gear requirement. Then judge for yourself.

YOURS ON REQUEST Folder illustrating gears Perkins has made — face gears, generated and curvic clutches; bevel, spiral, helical and spur gears; ratchets, sprockets and ground thread worms — from all materials. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

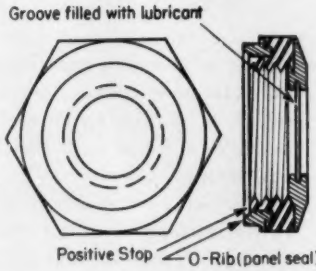
PERKINS
MACHINE AND GEAR CO.

Dept. 23 West Springfield, Mass.
Telephone: REpublic 7-4751

New Parts

(Continued from Page 159)

the panel and two O-ribs which form a double seal against the shaft. Prelubrication of the well between shaft O-ribs enables seal



to function at intermittent speeds up to 3600 rpm. Silicone rubber boot permits operation at temperatures from −120 F to 500 F. Models fit ⅛-in., ¼-in., ⅜-in., and ½-in. shafts with other sizes available on order. **Automatic & Precision Mfg. Co.**, 252 Hawthorne Ave., Yonkers, N. Y.

Circle 658 on page 19

Vinyl-Coated Metal

is available with many textures and colors

Texkote is a vinyl-coated metal available with finishes of various colors and textures. Metal thickness range is 18 to 30 gage. Coated material is well suited for applications such as luggage, appliances, automotive and aircraft trim, furniture, wall panels and cabinets. Textures are available that simulate wood grains, leathers, linens and other natural finishes. Coating has high abrasion and electrical resistance and is not affected by atmospheric conditions of heat and humidity. It may be deep drawn, roll-formed, punched and press-formed without damage. **Sun Steel Co.**, 1702 W. 74th St., Chicago 36.

Circle 659 on page 19

Pressure Switch

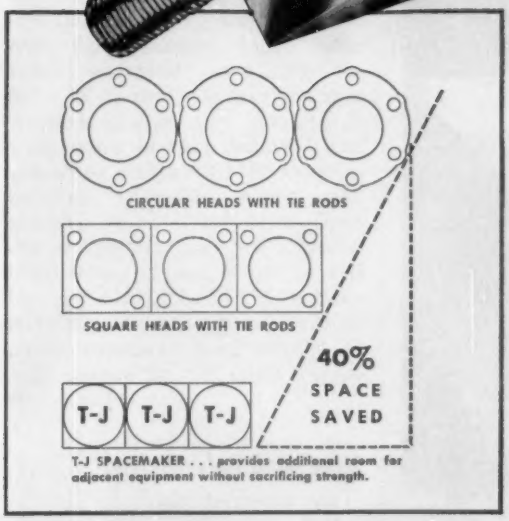
protects pumping system when pressure is lost

Low-pressure cut-off switch, rated at 1 hp, 110-220 v ac, opens an electrical circuit when pump pressure drops to 5 or 6 psi. Application is for protection of low-pres-

Saves 40% Space!

STRONGER, TOO

Than Outmoded Tie Rod Cylinders!



Only T-J Spacemaker CYLINDERS

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- Compact design eliminates tie rods, saves up to 40% space
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You'll find many answers to *automation* in your plant with T-J Spacemaker Cylinders! Designed with years-ahead features for top performance and dependability. Wide range of styles, capacities . . . for all kinds of push-pull-lift operations . . . reduces man-hours and costs! Write The Tomkins-Johnson Co., Jackson, Michigan.

NEW LITERATURE . . . send today for new Bulletin with complete details of Spacemaker line.

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G E SAVES 80%

with **GRC** tiny mating parts

Exclusive Gries techniques actually improved design and performance by die-casting this zinc-alloy threaded shaft and injection-molding the mating Nylon nut. Both units formerly were produced as screw machine parts, at 5 times the present cost. A typical demonstration of GRC's unique talent for doing big things with small parts . . . **economically!**

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NO MINIMUM SIZE!

MAXIMUM SIZES:

Nylon 1¼" long .03 oz.
Zinc Alloy 1¾" long ½ oz.

Quick deliveries on quantities of 100,000 to many millions

GRIES *World's foremost producer of small die castings*

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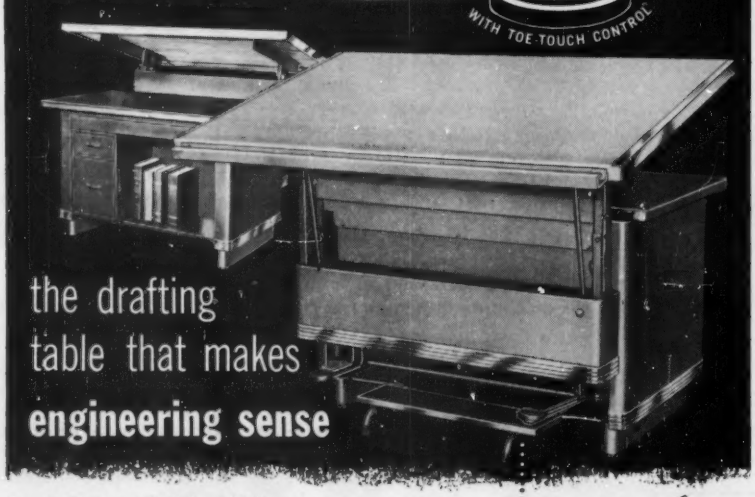
Circle 485 on page 19

NEW STACOR-*MATIC*

WITH TOE-TOUCH CONTROL



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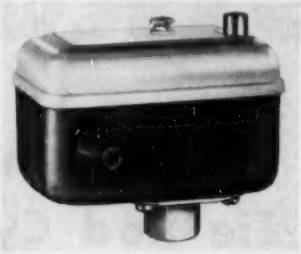
Circle 486 on page 19

New Parts

sure pumping systems. Switch is actuated by operating pressure from pump and interrupts line voltage to pump when pressure



drops to preset limit. Pumping is resumed by manually depressing reset button. Metal parts are either corrosion resistant or are cadmium plated to resist corrosive action. **Furnas Electric Co.,** 1000 McKee St., Batavia, Ill.

Circle 660 on page 19

Aluminum-Bronze Alloy

has high yield and tensile strengths

High mechanical properties and superior casting characteristics are provided by new high-strength aluminum bronze alloy known as Superston 40. Material is a two-phase (alpha-beta) alloy, composed of 75 per cent copper, 8 per cent aluminum, 2 per cent nickel, 3 per cent iron, and 12 per cent manganese. Alloy possesses high yield strength, great toughness (Izod notch impact strength of 18 to 30 ft-lb) and long fatigue-strength life. Whitish gold in color, alloy melts at 1814 F and can be readily cast, forged, rolled or extruded into intricate shapes. Tensile strength for sand castings is 92,000 to 98,000 psi, for centrifugal casting, 95,000 to 105,000 psi, and in the wrought condition, 100,000 to 135,000 psi. **Superston Corp.,** Ampco Metal Inc., Milwaukee, Wis.

Circle 661 on page 19

Irradiated Polyethylene

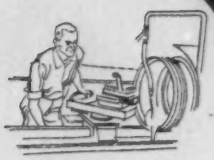
has high resistance to heat and chemicals

Vulkene 107-E is a vulcanized, carbon-black filled, reinforced polyethylene which is tough yet flexible, with physical properties and resistance to heat and chemicals

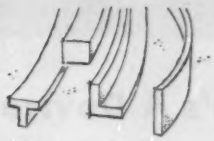
WHAT ARE AMWELD FLASH WELDED RINGS?

They are rings formed, flash butt-welded, and shaped into the finest quality circular weldments available.

They are rings that offer savings of critical materials. Bar stock formed and flash welded uses considerably less material than rings made by other methods.



They are rings that offer additional manufacturing savings. Since the rings are closer to the desired finished cross section, it is less expensive to machine them to a final dimension. Oh yes, Amweld will machine them for you.

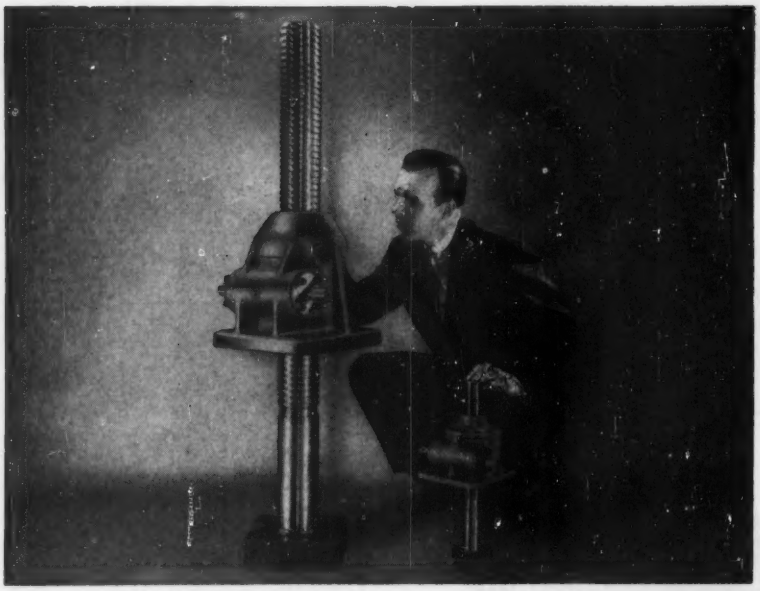


They are rings made by a company with experience in design. We can help you select a mill-rolled or extruded shape that is even closer to the finished ring dimension. This can give you additional savings.

Yes, Amweld flash-welded rings can give you extra profit from savings on material and machining time. Amweld rings can be made of most weldable ferrous or non-ferrous metals in sizes from 4 to 96 inches.

AMERICAN WELDING

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD, WARREN, OHIO

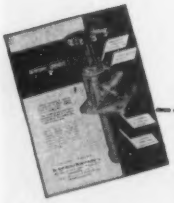


Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 6¾:1 to 27:1; turn of worm for each 1-inch raise, 10 to 40; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—adjusting welding positioners.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.



DUFF-NORTON Company

DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

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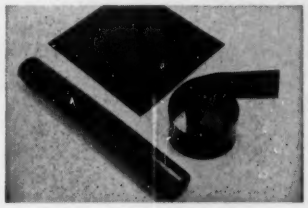
COMPANY _____ PHONE _____

ADDRESS _____

New Parts

superior to conventional high-pressure polyethylene. Yield strength at low temperature is double that of polyethylene, and creep deformation is reduced 90 per cent. Material has excellent heat stabil-



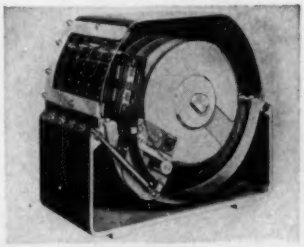
ity, retaining tensile strength of 500 psi to temperatures of 300 F. Electrically conductive, material may be used as semiconductor tape in shielded power cable, motor insulation and switch gear insulation. **General Electric Co.**, Chemical Development Dept., 1 Plastics Ave., Pittsfield, Mass.

Circle 662 on page 19

Cam Limit Switch

is externally adjustable while in motion

Type Al rotating cam limit switch with 15-amp contacts is designed to facilitate precise synchronization of multiple operations. Unit is made in three standard sizes accommodating up to 5, 9 or 12 cams. Split butterfly cams can be set with a spread between circuit make and break of 15 to 345 deg. External in-motion adjust-



ment of ±15 deg allows precise adjustment while equipment is in motion. Contact assemblies can have two sets of contacts, one normally closed and the other either normally open or normally closed. Fixed and moving contacts can be inspected from the outside through a transparent panel in oiltight case. Cams are individually adjustable and removable. Switch is designed to operate at

BOSTON Gear

7124

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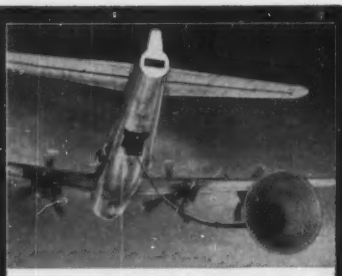
For nearest Distributor, look under "GEARS" in the Yellow Pages of your Telephone Book.

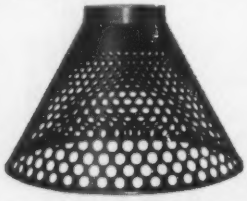
57BG



Fibermold

Quenches
Fuel-Thirsty Planes
for
FLIGHT REFUELING, INC.

Fibermold casts of high-impact plastic, the funnel-shaped Drogue that is of focal importance in mid-air refueling . . . for Flight Refueling, Inc. The Drogue, at the end of a length of hose trailing from the tanker, stabilizes the flight of the hose, and its 30-inch diameter provides a sizable target for the Probe on the fuel-thirsty receiving plane. Fibermold is proud to make this contribution to the extension of flight range and payload.



Fibermold puts its diversified experience to work producing high-quality, low-pressure laminates in volume for the aviation industry. Our sales engineers are prepared to assist you in designing, developing and producing aircraft structures fabricated of high-grade plastics . . . to meet your specific requirements.

Send for brochure, "Behind the Scenes" . . . complete digest of Hampden Brass's experience, equipment and facilities.

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DIVISION
Manufacturers of
High-Grade Reinforced Plastics

HB

HAMPDEN BRASS
AND ALUMINUM CO.
Established 1903
262 Liberty St.•Springfield, Mass.

Producers of Non-Ferrous Sand, Permanent Mold & Die Castings

Circle 490 on page 19

New Parts

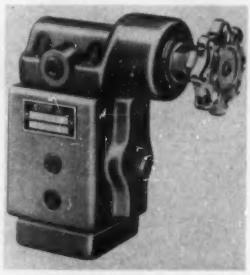
speeds to 1000 rpm, clockwise or counter-clockwise. It has an aluminum case and cadmium plate on all steel parts. Permanently lubricated antifriction shaft bearings absorb thrust and radial loads. **Clark Controller Co.**, 1146 E. 152nd St., Cleveland 10, O.

Circle 663 on page 19

Reducing Valve

provides controlled pressures of 25 to 1000 psi

Low-pressure type pressure reducing valve for oil-hydraulic systems has wide pressure adjustment range, providing controlled, reduced outlet pressures from 25 to 1000 psi. Valve is for use in hydraulic systems to provide con-

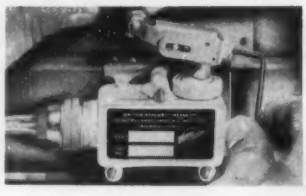


trolled maximum operating pressure for secondary circuits. For use with $\frac{3}{8}$-in. pipe size systems having operating pressures up to 2000 psi, valve is available with either gasket mounting or thread connections. Valve is nominally rated at 8 gpm flow capacity; bleed control is approximately 35 cu in. per min. **Vickers Inc.**, Box 302, Detroit 32, Mich.

Circle 664 on page 19

Snap Switch

has adjustable actuating arm



Snap switch, model H1-43, has adjustable actuator which permits fast installation and operating accuracy. Actuator arm can be ad-

SELF TAPPING SELF LOCKING

PHEOLL
SCHWEPPE STUDS
Patents Pending
CUT COSTS
1 ELIMINATE TAPPING
2 HOLD TIGHTER
3 CAN BE 'AUTOMATED'

WHEREVER a stud is specified, you can profitably cut production time and cost with self-tapping, self-locking Schweppe Studs. They also can replace bolts to advantage on many applications.

WHAT ARE SCHWEPPE STUDS?

They are double-ended studs made with dual thread-cutting slots at the lower end. Final threads on this end develop a positive frictional interference locking action on entering the hole.

HOW ARE THEY DRIVEN?

Schweppe Studs can be driven in an inexpensive *drilled* hole with any power stud driver. In one simple, continuous operation, they cut their own thread, drive, lock and seal.

WHAT ARE THEIR ADVANTAGES?

The *self-tapping* feature eliminates tapping time and thread inspection, tap wear and replacement, tap breakage and salvage time. The *self-locking* action of Schweppe Studs prevents loosening or backing out, even under extreme conditions.

WHAT ABOUT AUTOMATION?

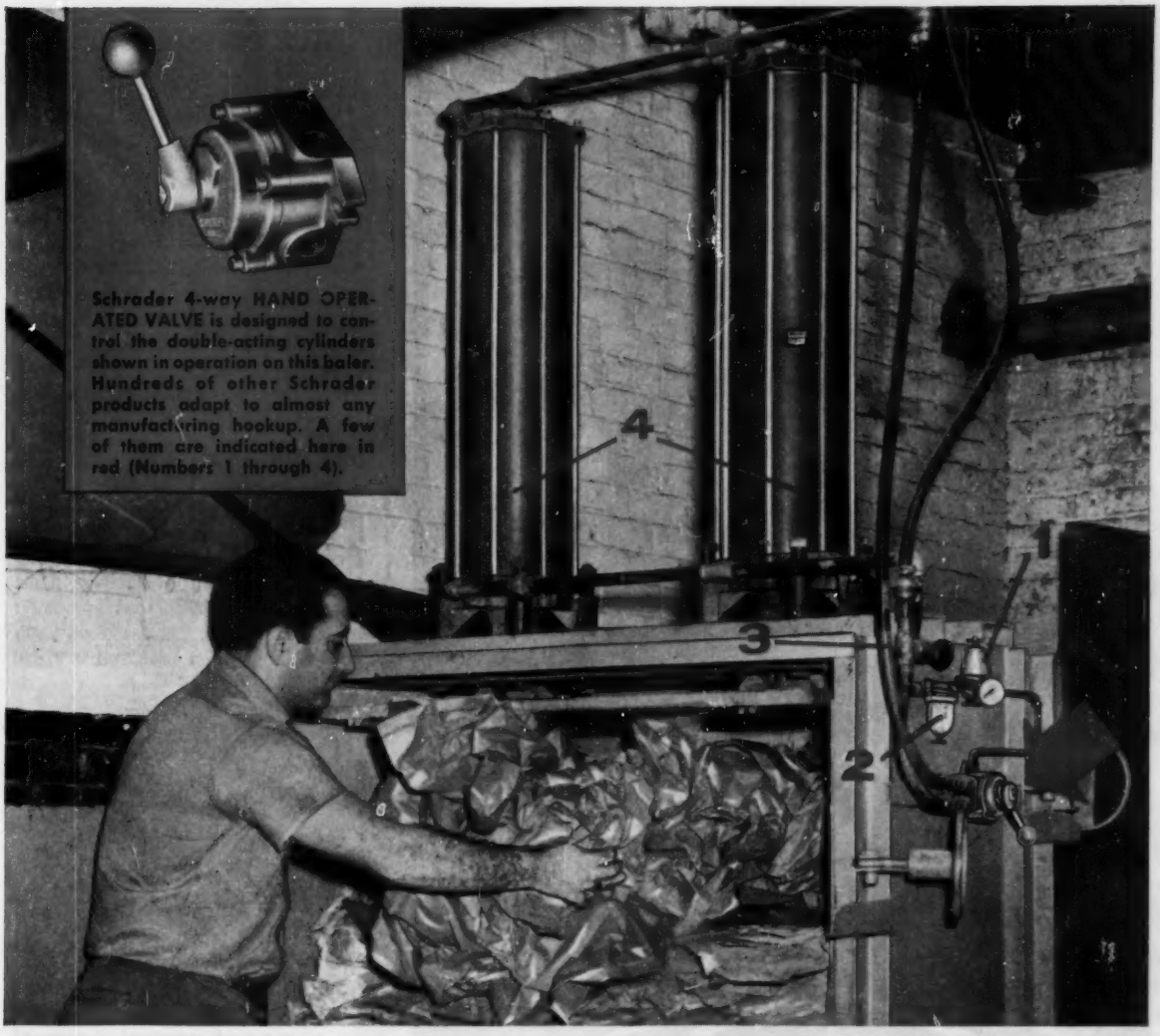
Since Schweppe Studs may be located accurately from the slotted end, they can be "hopperized" for automatic feeding and driving.

•To fit many applications, Pheoll Schweppe Studs can be furnished in a broad range of metals, finishes, sizes and thread styles. Learn how you can profit . . . find out about the many advantages . . .

Write for free Bulletin 1056

PHEOLL
MANUFACTURING COMPANY
SCREWS • BOLTS • NUTS
5706 Roosevelt Road, Chicago 50, Ill.

Circle 491 on page 19



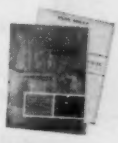
Schrader 4-way HAND OPERATED VALVE is designed to control the double-acting cylinders shown in operation on this baler. Hundreds of other Schrader products adapt to almost any manufacturing hookup. A few of them are indicated here in red (Numbers 1 through 4).

How Schrader Air Products bale paper, producing 4 ton pressure with 100 lbs. of air

At this Rhode Island dye works, the paper baling operation formerly was a fatiguing manual chore. Now, the operator simply fills the press with used paper and cartons, and pulls a 4-way hand valve. One hundred pounds of air pressure flowing through the two Schrader double-acting cylinders then compress the paper with four tons of force. Finger-tip adjustments can reduce or raise pressure quickly, easily.

Safe, simple, fast—compressed air daily performs miracles in hundreds of different ways. More and more manufacturers think "air" when they think "automation." Holding work, moving scraps, synchronizing actions—all such operations can be automated with Schrader Air Products.

Air means economy, too. Upon request, Schrader engineers will assist you in planning for the most efficient use of air and in selecting the products best suited to your applications. Tell us your problems. We'll be glad to help. Or send for the latest informative booklets.



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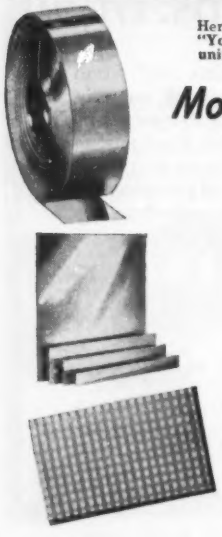
ESTABLISHED IN 1844

A. SCHRADER'S SON
Division of SCOVILL
470 Vanderbilt Avenue, Brooklyn 38, N. Y.

FIRST NAME IN THE USE OF AIR
FOR INDUSTRIAL PRODUCTION AND CONTROL

Circle 492 on page 19

Here's what Lightolier, 346 Claremont Ave., Jersey City, N.J. says: "Your Bakekote-coated polished brass gave us the freedom to design units which would otherwise have been prohibitive in price."



More Than a Metal—It's a Method

Whether *your* product is lighting, housewares, appliances, hardware specialties or stoves . . . in the 14 finish-to-base metal combinations of Nickeloid Pre-Finished Metals you will find the *right* design material to fit the scheme of your design theme. Nickeloid Metals offer new freedom in design, save production time, lower costs, reduce rejects.

Plan your design around these versatile metals — available in chrome, nickel, copper or brass finishes on base metals of steel, zinc, copper, brass or aluminum. Specify Nickeloid, the *modern* metal.

SEE FOR YOURSELF

Send for free Sampler-Selector, containing 8 actual metal samples and specifications.

NICKELOID METALS
SINCE 1898

American Nickeloid Co.
PERU 8, ILLINOIS

New Parts

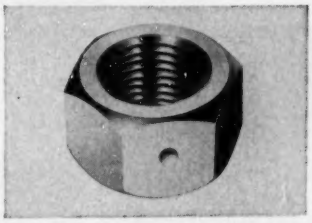
justed infinitely through an arc of 14 degrees and can be set before or after installation. Adjustment is made by adjusting screw and maintained by lock nut. Switch is hermetically sealed and has three-hole mounting. Unit is rated at 10 amps, 125/250 v ac, or 28 v dc inductive. Temperature range is −100 to 250 F. **Electro-Snap Switch & Mfg. Co.**, 4218 W. Lake St., Chicago 24.

Circle 665 on page 19

Lock Nut

center-locking unit in wide size range

Two-way lock nut has locking action in center of body. Unit is double chamfered and will start from either end. Nut offers positive locking when bolt end is flush



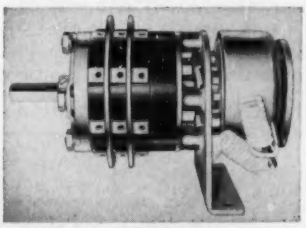
with nut, or when all threads are not utilized. Opposing thread deflection and ovalizing in center allows 180 degree spring for holding power and constant degree of torque consistency. **MacLean-Fogg Lock Nut Co.**, 5535 N. Wolcott St., Chicago.

Circle 666 on page 19

Rotary Switch

multipole unit is solenoid operated

Solenoid-operated heavy duty rotary multipole switch is assembled with solenoid rotating de-



vice that drives the switch through cycle of contact positions. This

Circle 493 on page 19

What shape is a quality fastener?

Here is a handful of ELASTIC STOP® nuts. Each has ESNA's familiar red locking collar . . . is self-locking and vibration-proof. Each is a readily assembled, one-piece unit. Each provides positive protection against thread corrosion . . . prevents liquid seepage along bolts. Each is made from the finest of raw materials. Each is exactly controlled as to finished dimensions, class of thread fit and finish. Each is now in use on critical applications, with a record for uniform high quality that is unmatched.

Most of them are standard parts. Some originated as the result of a specific request for ESNA's help with an important fastening problem.

Isn't it logical to call on us with your next fastening problem?

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA TRADE MARK

ROLLPIN TRADEMARK

Elastic Stop Nut Corporation of America
Dept. N62-160, 2330 Vauxhall Road, Union, N. J.
Please send the following free fastening information

☐ ELASTIC STOP nut bulletin ☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____
Firm_____
Street_____
City_____ Zone_____ State_____

CASE HISTORY 1

REQUIRED:

A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:

Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

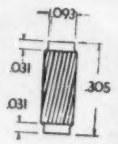
CASE HISTORY 36

REQUIRED:

Less costly manufacturing method for this small stainless steel fluted pin which cost $19.20 per M as a screw machine product.

HASSALL SOLUTION:

Cold forming by Hassall at a cost of $2.95 per M gave the customer an 85% cost reduction on this part.



SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

CASE HISTORY 89

REQUIRED:

Customer looking for low cost, high production rate method of producing mandrels for rotary dental brushes.

HASSALL SOLUTION:

Hassall-originated design for cold-heading replaced chamfered end with tumbled, round end; maintained rigid specifications for straightness and made low-cost production possible.

Multiply these case histories a thousandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier—can show you substantial savings, better deliveries and technical assistance on your small parts and fasteners.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 2197 Westbury, Long Island, New York.

CASE HISTORY 37

REQUIRED:

Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:

The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

HASSALL

SINCE 1850

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

New Parts

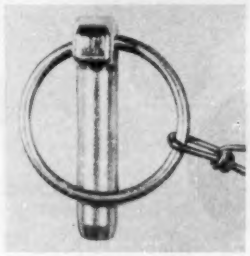
provides remote, automatic or semiautomatic control of a series of complex circuits. Indexing stroke of solenoid device is matched to degree of rotation between contact positions of switch and drives rotor one position each time solenoid circuit is closed. Circuit may be closed by pushbutton or simple mechanical motion. Switch may be custom built to customer's specifications. **Electro Switch Corp.**, 167 King Ave., Weymouth 88, Mass.

Circle 667 on page 19

Retaining Pin

is held in place by snap ring

Klik-Pin is retained in place by a tempered-steel snap ring which clicks over the end of shaft in which pin is inserted. Snap ring is wound so that direction of spiral keeps ring firmly closed down



against pin. Holes for ring ends are only partially drilled through pin, allowing ends of pin to bottom in holes. This provides a pivotal bearing and increases snap action of ring. Pins are forged high-carbon steel, heat treated, and are available in ¼ and 7/16-in. sizes with two ring diameters and optional retaining chain. **Danuser Machine Co.**, Fulton, Mo.

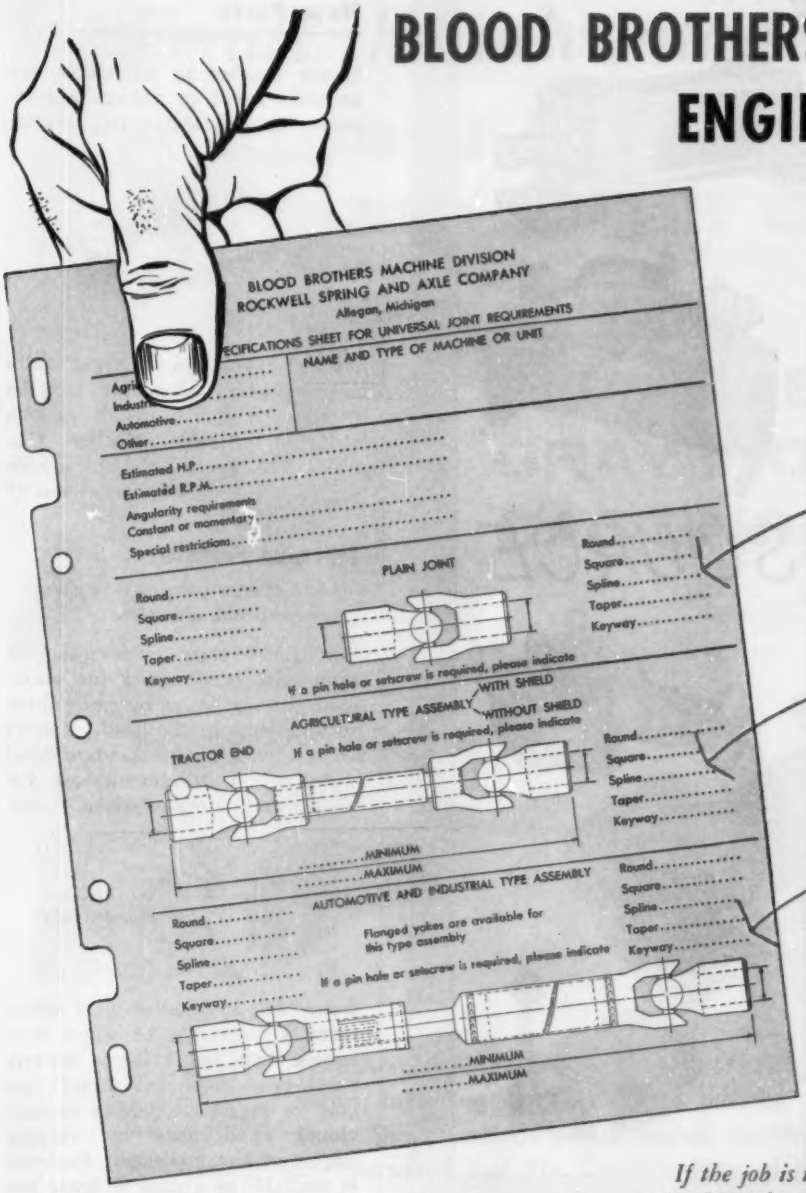
Circle 668 on page 19

DC Motor

subminiature unit has 7/8-in. diameter

Miniature dc motor or generator is ⅞-in. diam by 1⅝-in. long with a 0.098-in. diam shaft. Self-aligning sleeve bearing with nylon retainer, or optional ball bearings, carry hardened, chrome-plated, ground and lapped shaft. Stator is Alnico V-ring type. Brush

BLOOD BROTHERS makes your ENGINEERING JOB *EASIER*



. . . regardless of whether your project requires a single universal joint such as this

. . . a complete agricultural type assembly

. . . or an automotive or industrial truck propeller shaft like this

Just fill out and mail a sheet like *THIS*—and let BLOOD BROTHERS' Engineers propose a helpful, practical solution to your Drive Line Problem!

If the job is unusual or the problem unique, Blood Brothers' experience can be invaluable.

Many engineers are saving valuable time—right at the start of a project—by filling out and returning a "Spec Sheet" like this to Blood Brothers. Why not try it?

With your power transmission requirements in mind, our engineers will make recommendations and submit engineering drawings. You save designing and drafting time, and perhaps forestall problems, by having the initial teamwork of experienced specialists.

This service is offered without extra charge because *we* can work more efficiently with all the facts in hand.

Blood Brothers builds *more standard types and sizes* of universal joints than any other manufacturer (from 300 up to 89,300 torque inch pounds continuous load).

Why not use this experience on your next project? *Write Blood Brothers today for your handy "Spec Sheets."*

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ROCKWELL SPRING AND AXLE COMPANY
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One source for component parts really pays off... coordinated shipments, the same high quality standards, one responsibility are just a few of the many advantages. H-P-M is the source for a complete line of pumps, power units, valves, cylinders and system accessories. H-P-M's experience background in the design and building of hydraulic systems can be a real help when needed. Write today for a complete catalog. Ask for Bulletin 1101. Make H-P-M your standard for savings.

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THE HYDRAULIC PRESS MFG. CO.
Mount Gilead, Ohio, U.S.A.
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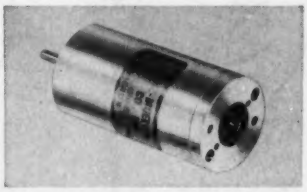
NFPA NATIONAL FLUID POWER ASSOCIATION

Circle 497 on page 19

New Parts

holder bracket is adjustable for accurate speed or voltage adjustment for clockwise or counter



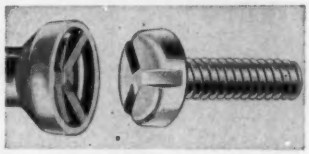
clockwise rotation. Larger units are available. All motors may be fitted with gear-heads of various reductions. **Heinz Mueller Co.**, 1906-08 N. Cicero Ave., Chicago 39.

Circle 669 on page 19

Threaded Fastener

head design permits tamperproof assembly

Hold Head screw for tamperproof equipment is designed for maximum driving power by using three or four slots in the head. Screws are available in all standard head styles. Unit is advantageous for enclosed "factory-adjusted" elec-



tronic and mechanical units which carry a warranty, or where protection from tampering is desired. Screw-head slots and driver lugs may be keyed exclusively to individual applications by varying angles of slot spacings. Fastener is available as a steel or brass machine screw with 3 or 4 slots, types A and B sheet metal screws, type C thread-forming screws, and type 1, 23 and 25 thread cutting screw. **Central Screw Co.**, Dept H, 3501 S. Shields Ave., Chicago 9.

Circle 670 on page 19

Edge Control

photoelectric unit controls transparent materials

Photoelectric edge-guidance system, called Linar Edgetrol, is completely self-contained and fully automatic. Seven different sensing heads available enable system to operate with any material or con-

NOW—all the advantages of
Permanent Molding—plus Intricate Shell Coring *in*

EATON PERMANENT MOLD GRAY IRON CASTINGS

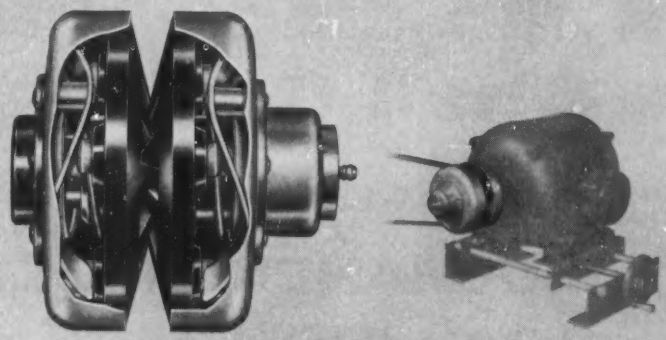
PERMANENT MOLD GRAY IRON CASTINGS meet critical quality requirements, including intricately cored sections, in a wide range of applications. These castings permit higher machining feeds and speeds, with substantially increased tool life. Characteristics of these castings include dense, non-porous, homogeneous structure, freedom from inclusions, excellent tensile strength, and the ability to take high surface finishes.

These qualities particularly recommend Eaton Permanent Mold Gray Iron Castings for such uses as high pressure control mechanisms, refrigeration and air conditioning parts, power steering and power braking components, household appliance parts, pump bodies, hydraulic cylinders, and countless other critical applications.

If you have applications where more than ordinary quality is required, our engineers will be happy to work with you.

EATON MANUFACTURING COMPANY
FOUNDRY DIVISION
VASSAR, MICHIGAN

striving for **SIMPLICITY?**



here's how **HI-LO** *helps*

Design-wise, HI-LO automatic variable speed pulleys help you reduce complex design problems. Functionally, they're first choice of many design engineers for a wide range of applications. The simple, positive action of cam followers on cams is the mechanical action that takes place in maintaining the pitch diameter setting regardless of load—an exclusive feature of HI-LO pulleys. Springs in HI-LO pulleys are not driving members as in most spring-loaded pulleys, but serve primarily to keep the pulley faces in contact with the belt.

For *FREE* technical manuals with diagrams, descriptions of applications and other power transmission data, write:

Equipment Engineering Company

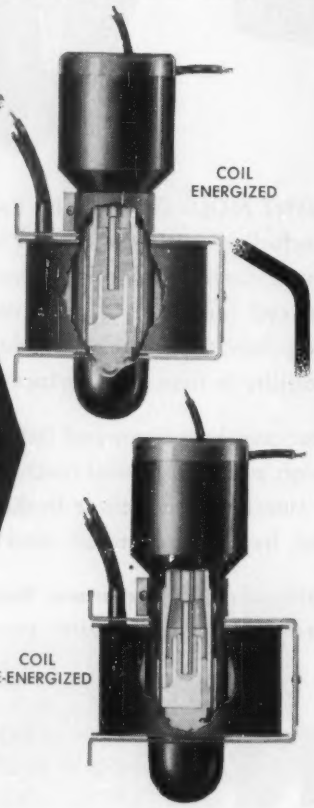
2855 Columbus Ave., Minneapolis, Minnesota

Circle 499 on page 19

The
TIMER RELAY
that handles all controlled timing problems . . .

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer

Durakool®
STEEL MERCURY TIMERS



This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.

See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

Circle 500 on page 19

New Parts

dition. No force or pressure is applied to material being controlled. Use is for machines doing accurate printing, coating, tubing, rerolling, slitting, punching and similar operations on continuous opaque or porous materials. System will control edge of materials such as lace, gauze, screening, netting and films such as polyethylene and cellophane. Unit maintains accuracy within 1/32-in. at any speed. **Intercontinental Dynamics Corp.**, 170 Coolidge Ave., Englewood, N. J.

Circle 671 on page 19

Adhesive

bonds rubbers to metals in one coat

Chemlock 220 and 201 are versatile adhesives for permanent bonding of uncured natural and synthetic rubbers to metals with a one-coat application. A bond is produced giving greater strength than obtained with conventional two-coat adhesives under comparable environmental conditions. A superior bond resistance to adverse environmental conditions, such as wide temperature variations, hot and cold water, salt spray, chemicals, solvents and corrosive atmospheres, is obtained by using Chemlock 201 as a primer. Adhesives will bond natural rubber, GRS, neoprene, Buna N and butyl to carbon or alloy steel, stainless steel, aluminum alloys, magnesium alloys, copper, brass, die-casting alloys, plated metals and rigid plastics. Adhesives may be applied to metal parts at room temperature by brushing, spraying, dipping or rolling. Resultant surface is nontacky and resistant to wiping in molding operations. Coated parts may be stored up to

IN AIR CYLINDER OPERATION BELLOWS GIVES..

ALL THE ADVANTAGES OF INTEGRAL VALVING WITH EITHER 8 or 115 VOLT BUILT-IN CONTROLS

The Bellows Air Motor with the built-in 8-volt directional valve revolutionized the use of pneumatic circuits. Here for the first time was an air cylinder with directional valve, speed control valves, and electrical actuators built-in . . . to form one compact, streamlined power unit—offering instant action, positive control.

That same positive control is also available with built-in 115-volt directional valve control. The 115-volt unit offers all the advantages of compact design, instant action, proven so popular in the 8-volt unit.

Here is air cylinder power at its best—air cylinder power free of bulky power solenoids, of cumbersome piping, of complex circuitry—air cylinder power that goes hand in glove with today's streamlined design.

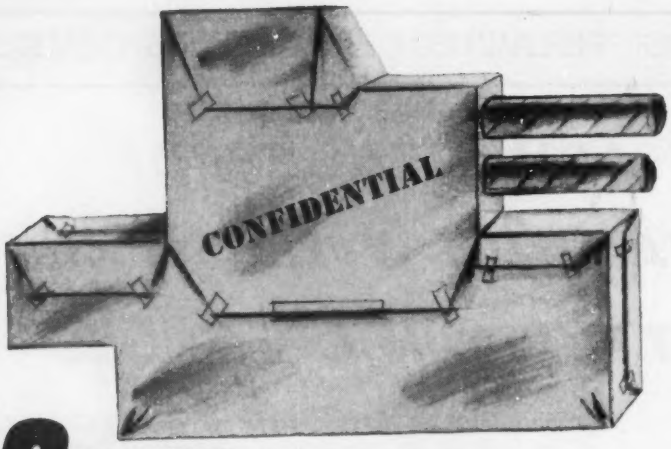
WRITE FOR THESE TWO BOOKLETS

Fifty pages of data to help you select the right air motor-valve combination for your job. Address: The Bellows Co., Akron 9, Ohio (Dept. MD-157).

In Canada: Bellows Pneumatic Devices of Canada, Ltd., Toronto, Ontario.

The Bellows Co.
AKRON 9, OHIO

7348



Sure *we built it...*

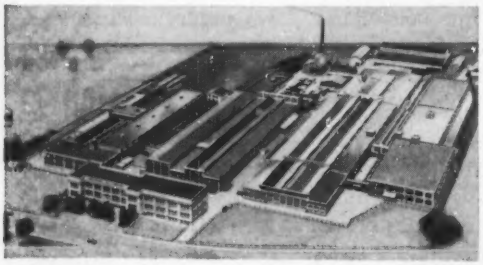
—and we're proud of it but we can't show it!

We worked out many of the design problems from the user's basic idea . . . adapted some applications learned by experience in an entirely different field . . . suggested ideas and procedure to meet his specific requirements . . . then built 16 units. Result? — the customer saw his dream come to life, speeding his entire plant's production, simplifying handling, and lowering man-hour costs.

But that's as much as we can tell about his process because it was a "strictly confidential" job.

If you need help on special machine design and production, you'll find us loaded with "ideas-PLUS" . . . ideas, yes, PLUS the know-how, experience and facilities to handle the entire job in one plant. And if you want your processes or plans held in confidence, we're accustomed to working that way, too!

Our Facilities Include:



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INDUSTRIAL DIVISION
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CGc ATLANTA CLEVELAND DALLAS KNOXVILLE MEMPHIS MOBILE NEW YORK 17

New Parts

four weeks before further processing without affecting quality of bond. **Lord Mfg. Co.**, 1635 W. 12th St., Erie, Pa.

Circle 672 on page 19

Ball Bushing

operates over supported shaft

Open-type ball bushing has a longitudinal section removed from circumference to permit use of shaft support members along length of shaft. Unit has open sector equal to width of one ball circuit. Con-

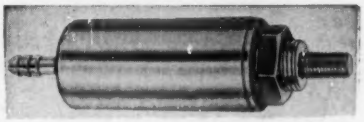
struction eliminates shaft deflection and is recommended where extreme rigidity or unusually long shafts are required. Compensation for wear is also possible. Bushing is available in bore sizes from 1 to 3 in., housing bore sizes from 1⅝ to 4½ in., and lengths from 2¼ to 6 in. Rated rolling load capacity is 202 to 2000 lb. **Thomson Industries Inc.**, Manhasset, N. Y.

Circle 673 on page 19

Air Cylinder

nonrepair unit has drawn cylinder

Model 091 nonrepair air cylinder is a single-acting, spring-return unit which features new low-cost method of construction. Unit has a vinyl U-cup mounted in aluminum alloy piston. Body is a stain-

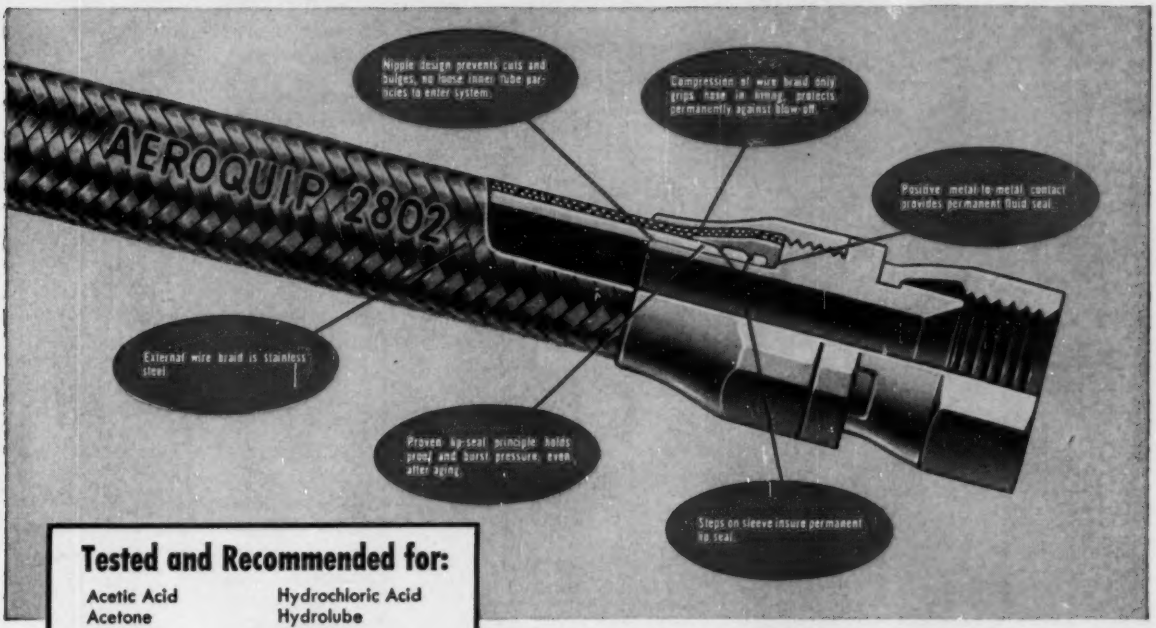


less-steel drawn cup with interior finish of 10 mu in. max. Air-hose adaptor is securely fastened in hole pierced in bottom of cylinder cup. Piston rod guide closes open end of cylinder and is permanently secured by the edge of the cup which is rolled into a circumferential groove on the guide. Cyl-

Circle 502 on page 19

Aeroquip Announces 2802 Teflon* Hose with Reusable "*super gem*" Fittings

NOW YOU CAN ASSEMBLE TEFLON HOSE AND LEAKPROOF FITTINGS BY HAND!


AEROQUIP 2802
Nipple design prevents cuts and bulges, no loose inner tube particles to enter system.
Compression of wire braid only grips hose in serrations, protects permanently against blow-off.
Positive metal-to-metal contact provides permanent fluid seal.
External wire braid is stainless steel.
Proven lip-seal principle holds proof and burst pressure, even after aging.
Steps on sleeve insure permanent lip seal.

Tested and Recommended for:

Acetic Acid	Hydrochloric Acid
Acetone	Hydrolube
Air, Hot	Ketones
Alcohols, Aliphatic	Lacquers, Solvents
Ammonia, Aqueous	Lindol, Cellulube
Aqua Regia	Lube Oil, Hot
Asphalt	Mercury
Benzene (Benzol)	Naphtha
Carbolic Acid, Hot	Naphthalene
Chlorinated Solvents	Nitric Acid
Chlorine (wet or sol.)	Pydraul F-9
Creosote Oil	Steam
Ethers	Sulphur Dioxide
Furfural	Sulphuric Acid
Gasoline, Sour or Ref.	Trichlorethylene
	Touluene (Toluol)
Hydraulic Oil	Water, Fresh or Salt (hot or cold)
Hydrobromic Acid	

For temperatures from —65° F. to +450° F. Operation beyond these limits subject to Aeroquip approval.

New Aeroquip 2802 Industrial Teflon Hose and Reusable "*super gem*" Fittings make possible wide use of Teflon hose lines for fluid systems subject to extreme temperatures and corrosive fluids. No expensive swaging machines are required. To make Teflon hose lines, just attach the "*super gem*" Fittings to Aeroquip 2802 Hose using ordinary hand tools. It takes only minutes to assemble a factory-quality Teflon hose line right in your plant. "*super gem*" Fittings are economical because they can be detached and used again and again.

For full technical information on Aeroquip Teflon Hose and Reusable "*super gem*" Fittings, write for Bulletin IEB-26.

"*super gem*" is an Aeroquip Trademark. *DuPont trade name for its Tetrafluoroethylene resin.

Aeroquip
REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 15, ONTARIO

LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD • AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

manual, oil or air-actuated ...for unbiased* friction clutch recommendations, consult Twin Disc!

Manually-Actuated

Oil-Actuated

Air-Actuated

*Unbiased recommendations . . . because whether your operation calls for a manual-, oil-, or air-actuated clutch, all are available from Twin Disc. More important, Twin Disc also makes a complete line of fluid drives, including torque converters—both single-stage and three-stage—for applications from 30 to 1000 hp . . . as well as fluid couplings for engines and motors from ¾ to 850 hp. For every industrial power transmission requirement—friction or fluid—consult Twin Disc *Specialists*.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois
Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Tulsa

New Parts

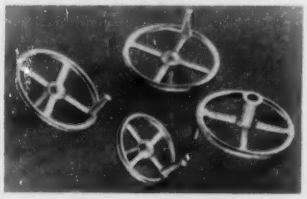
inder exerts a force equal to 0.9 air-line pressure and maximum stroke is 1 in. **Bimba Hardware & Mfg. Co.**, 101 Main St., Monee, Ill.

Circle 674 on page 19

Hand Wheels

standardized units from 1 to 1 3/4 in. OD

Standard zinc diecast hand wheels, winch wheels and steering wheels are for use on appliances, power tools and electronic equipment. Trunnion pins, hub lengths, hub



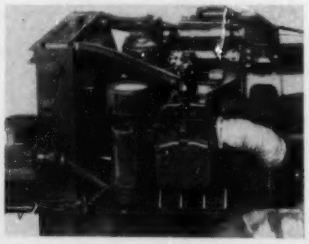
diameters, hole diameters and shapes may be varied to suit individual requirements. Wheels are solid one-piece units and are produced ready for installation or plating. Sizes are 1, 1¼, 1½ and 1¾ in. OD. **Gries Corp.**, New Rochelle, N. Y.

Circle 675 on page 19

Diesel Engine

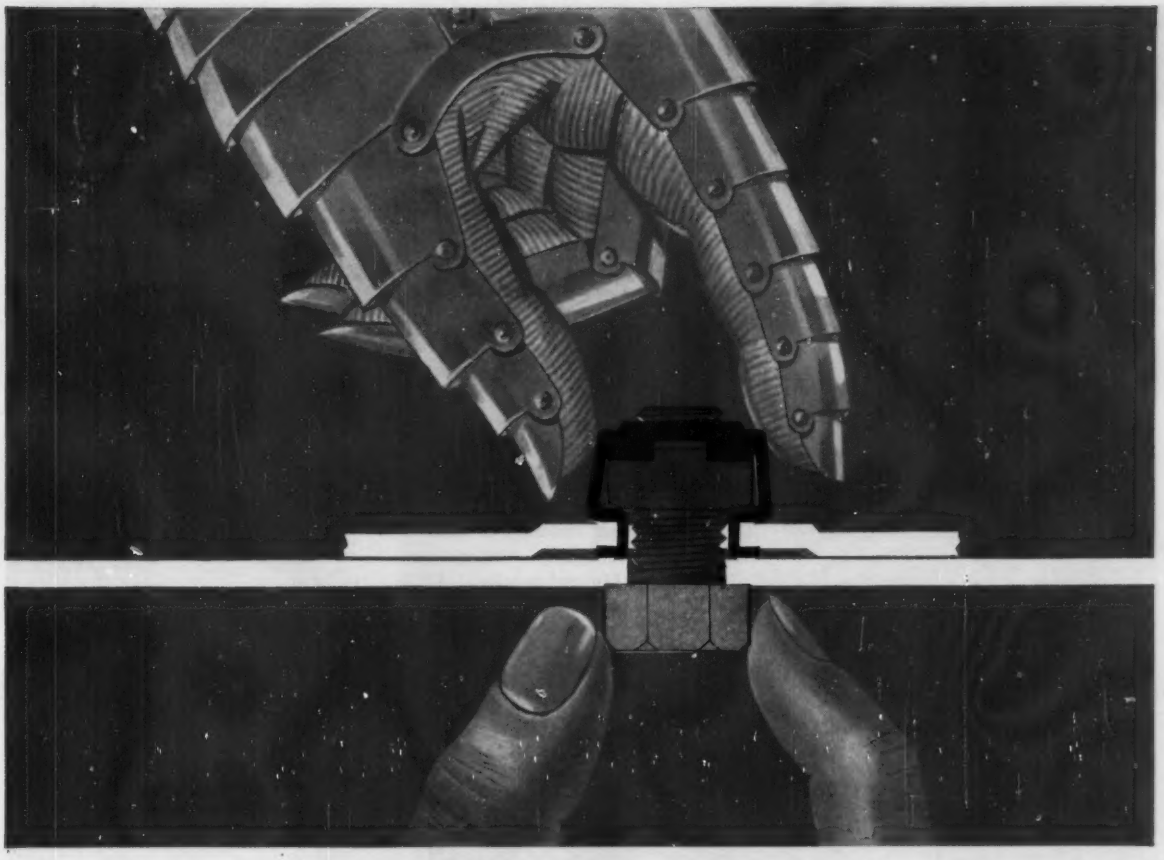
low profile unit delivers 24 hp

Horizontally-opposed, two-cylinder diesel engine has low profile (only 25¼ in. high) for installations where space must be conserved. Support pads are spaced far apart and located below the crankshaft centerline, close to center of engine mass. Engine weight is concen-



trated near mounting pads to assure positive anchorage in high-speed transport equipment subjected to severe shock. At 1800 rpm, engine produces 18 hp for continuous 24-hour service or 24

Circle 504 on page 19



FINGERS OF STEEL
that hold where you can't reach

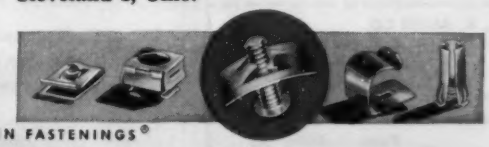
If you can't reach the back of a panel to hold a nut, let the spring steel fingers of a Tinnerman SPEED GRIP® Nut Retainer hold it for you. No welding or staking, no special skills or equipment required. It's the most efficient way to attach a square nut to a panel in blind location.

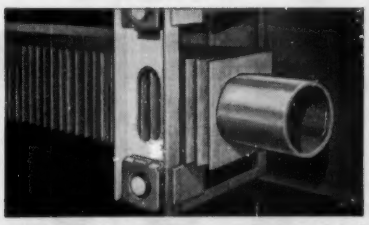
The SPEED GRIP combines a square nut retained in a spring steel cage. The SPEED GRIP snaps easily into the panel. Expensive rigid position methods are eliminated. Nut floats free in the cage to offset minor hole misalignments, but cannot turn as bolt is tightened.

SPEED GRIPS can be put on anywhere along your assembly line . . . no side trips to special stations, no line deviations of any kind. Rustproofed, they can be applied after painting, ending costly masking or retapping of paint-clogged threads.

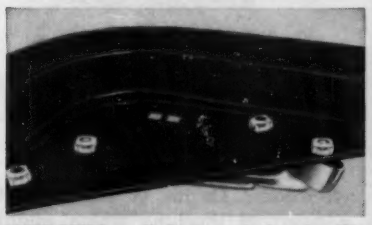
Consult your Tinnerman representative soon and write for Bulletin No. 335. **Tinnerman Products, Inc., Box 6688, Department 12, Cleveland 1, Ohio.**

TINNERMAN
Speed Nuts
FASTEST THING IN FASTENINGS®





SPEED GRIPS eliminate several punched and tapped holes, cut assembly costs 78%, simplify installation of heater.



SPEED GRIPS applied *after* painting simplify blind-location assembly of auto seat handle, avoid paint-clogging of threads.

SPEED GRIPS cut costs 75% by replacing tapped holes and weld-type nuts as mounting fasteners on car radio.

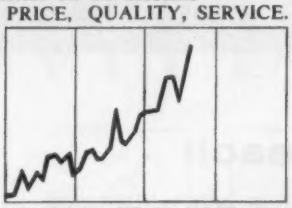
Does VOLKSWAGEN bother Cadillac?

We don't make CADILLAC air cylinders and we don't pretend that we do...

We do claim that we make very good cylinders at very good prices:

BORE	BASIC PRICE	ADD PER " OF STROKE
1⅛"	$15.50	$.35
1½"	$20.50	$.50
2"	$25.50	$.55
2½"	$29.50	$.65
3"	$32.50	$.95
4"	$47.50	$1.20

We furthermore claim that we work hard to ship from stock and our sales chart tells us that we are being successful on all accounts — PRICE, QUALITY, SERVICE.



Besides cylinders, we also make the ALLENAIR line of AIR VALVES, AIR CLAMPS and DIAL FEED TABLES and if we could tell you right here all there is to tell you about what we offer and how those products can increase your PRODUCTION at MINIMUM COST we wouldn't need the $1.25 24-page catalogue that is available for free this month to anyone seriously interested.

THE A. K. ALLEN CO. MD-17
57 Meserole Ave., Brooklyn 22, N. Y.
Name.....
Company.....
Address.....
City.....Zone.....State.....

P.S.—*The cylinder pictured is a Factory Reject. The only rods available are straight ones and made out of #416 Stainless Steel ground and polished stock and repolished after machining. The bearing is nylon.*

The answer to the question on top of this page is: *Not one bit. There is a market for both!*

ALLENAIR THE A. K. ALLEN CO.
57 Meserole Ave., B'klyn 22, N. Y.

Circle 506 on page 19

New Parts

hp for intermittent service. Speed range is 600 to 2400 rpm, providing flexibility for all types of equipment. Water-cooled, 4-cycle unit has 4-in. bore, 4-in. stroke, and displacement of 100.5 cu in. Size is 28⅝ in. long and 39 in. wide; weight is 700 lbs. **United States Steel Corp.,** Oil Well Supply Div., 2001 N. Lamar St., Dallas, Tex.

Circle 676 on page 19

Motor Bracket

offers economies in assembly

Motor mounting bracket eliminates previous three-part design and offers assembly economies. Unit has four-point holding power and high torque resistance. Under con-

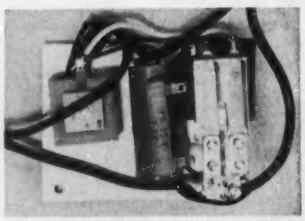
tinuous torque tests, bracket withstood thousands of motor starts with no indication of slippage or loss of grip on motor mounting ring. Bracket is snapped into place by hand with a screw driver or similar hand tool. **Prestole Corp.,** 1345 Miami St., Toledo 5, Ohio.

Circle 677 on page 19

Impact Switch

protects 110 v system from impact shocks

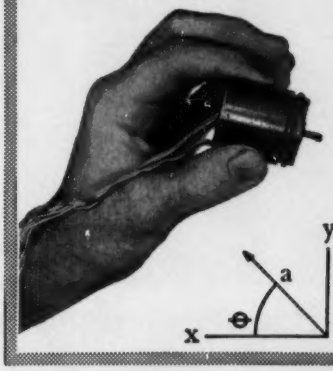
Impact disconnect device breaks circuit and makes a machine inoperative during excess shock or



vibration. Device is mounted at a point in machine which might be vulnerable to shock. Upon impact, the circuit is opened and

TELESYN® 400 CYCLE RESOLVERS

from FORD INSTRUMENT



- **STANDARD RESOLVERS** in Sizes 15 and 23.
- **RESOLVER SYSTEMS** incorporating size 23 resolvers, network box and amplifier.
- **and SPECIALS** designed to the particular application.

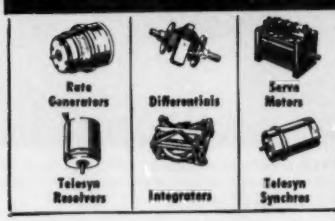
Ford Instrument's *Telesyn* Resolvers — precision-built for the extreme efficiency and accuracy of the Company's computers and control systems — are available to meet your *own* quality requirements.

FREE — Fully illustrated data bulletin gives specifications and performance information. Please address Dept. MD.

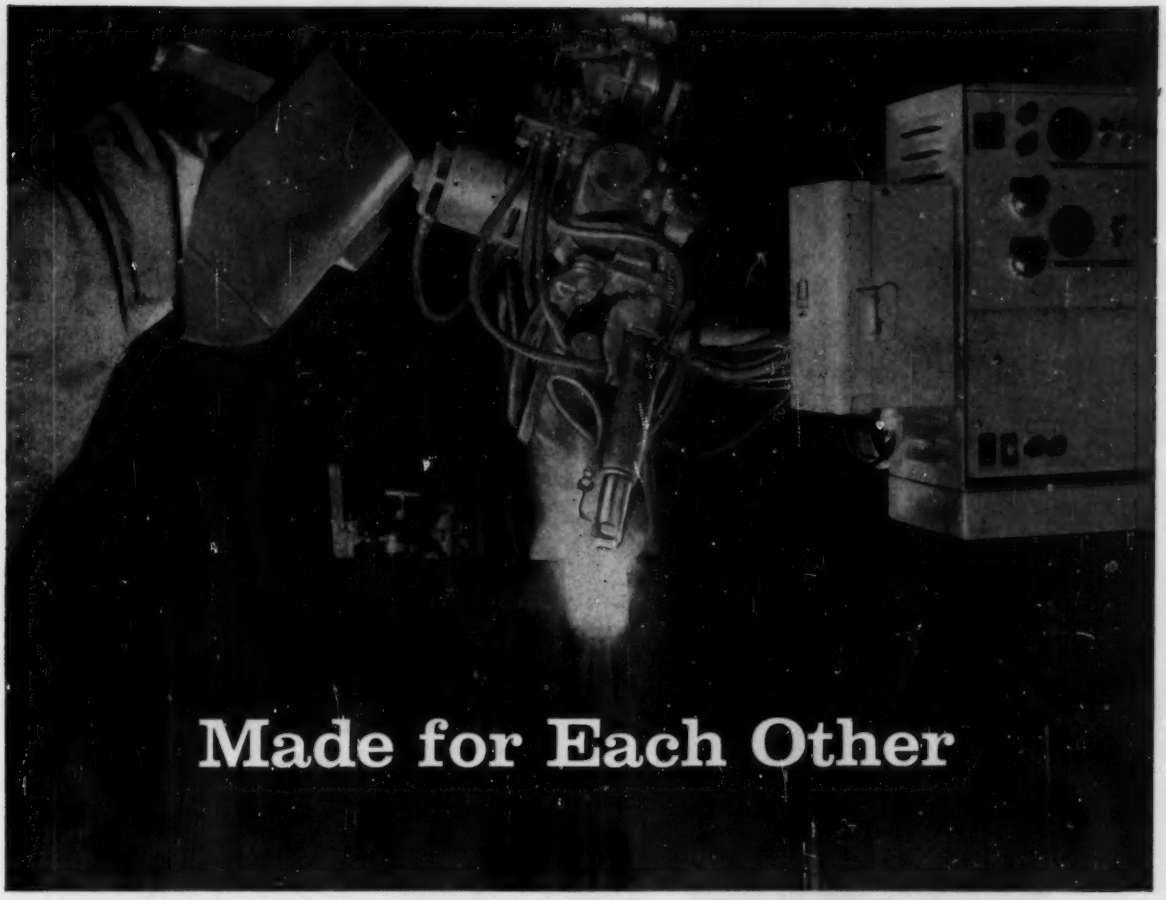
69A

FORD INSTRUMENT COMPANY
Division of Sperry Rand Corporation
31-10 Thomson Ave.
Long Island City 1, N. Y.

Ford Instrument's standard components



Circle 507 on page 19



High-speed sigma welding a 5-in. thick alloy paper mill roll. Note top quality of multipass weld beads.

. . . SIGMA WELDING AND ALLOYED METALS

Because sigma welding joins modern alloys of varying types and thicknesses in fast, clean operations, it has gained recognition by manufacturers throughout industry as the most efficient welding process for a wide range of alloy fabricating jobs.

Combines Advantages

Sigma welding is an extremely versatile process—it joins metal alloys ranging in thickness from 0.035 inch to more than five inches (in multipass operations)—and attains up to four times faster wire deposition than other welding processes.

Gain the full advantages of modern sigma welding . . . Contact your local LINDE Representative for complete information, or write today for free literature.

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.

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The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Linde
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With National Seals

Quality control isn't a myth— it's a crusade!

At National, quality control is based on the oil seal industry's most rigid manufacturing specifications. It begins with critical examination of raw materials. It includes constant checking of form tools and molds. It extends to exhaustive optical examination of all seal components by an exclusive process developed at National. (In this process, seals are cast and cross-sectioned, and an optical comparator used to show exact shape and position of every seal part, mounted on the shaft or unmounted.) And always, there are extensive and continuing operating and "leak" tests of finished seals.

For proved dependability, specify National seals. And for prompt, knowledgeable help on sealing problems, call your factory-trained National Seal engineer.

NATIONAL SEAL Division, Federal-Mogul-Bower Bearings, Inc.

General Offices: Redwood City, California; Plants: Van Wert, Ohio and Redwood City, California

National Field Engineers At Your Service: Chicago, Ill., Room 462, McCormick Building, HArrison 7-5163 Cleveland, Ohio, 210 Heights Rockefeller Bldg., YEllowstone 2-2720 • Dallas, Texas, 2520 West Mockingbird Lane, FLeetwood 2-7541 • Detroit, Mich., 13836 Puritan Avenue, VErmont 6-1909 • Downey (Los Angeles Co.), Calif., 11634 Patton Rd., TOpaz 2-8163 • Indianapolis, Indiana, 2802 North Delaware St., WAlnut 3-1535 • Milwaukee, Wis., 647 West Virginia Street, BRoadway 1-3234 • Newark, N. J , 1180 Raymond Blvd., MItchell 2-7586

4062

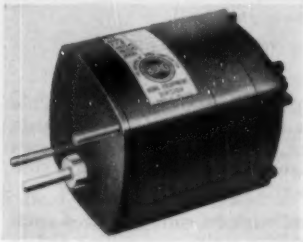
held open during the shock period. Resetting after shock ceases is automatic. Unit consists of a relay, resistor, condenser and rectifier mounted on a plate with male plug and female receptacle for direct connection in a 110 v circuit. Size of unit is 3 x 4 x 2¼ in. **Fred Hebel Corp.**, Addison, Ill.

Circle 678 on page 19

Miniature Motor

is available with or without gear-head

Subfractional horsepower electric motor for precision instruments is available in a range from 1/2000 to 1/750-hp in both synchronous and induction types, with or without gear trains. Motor is rugged and dependable and is designed

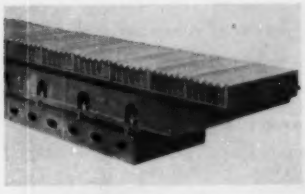


for applications in the industrial TV, recorder and instrument fields. End bells and gear-train cases are diecast alloy, precision machined to form a totally enclosed housing. Geared output shafts have two bearing supports to accomodate radial loading. All gears are hobbed and rotors are ball-bearing mounted. **George W. Borg Corp.**, Borg Equipment Div., Janesville, Wis.

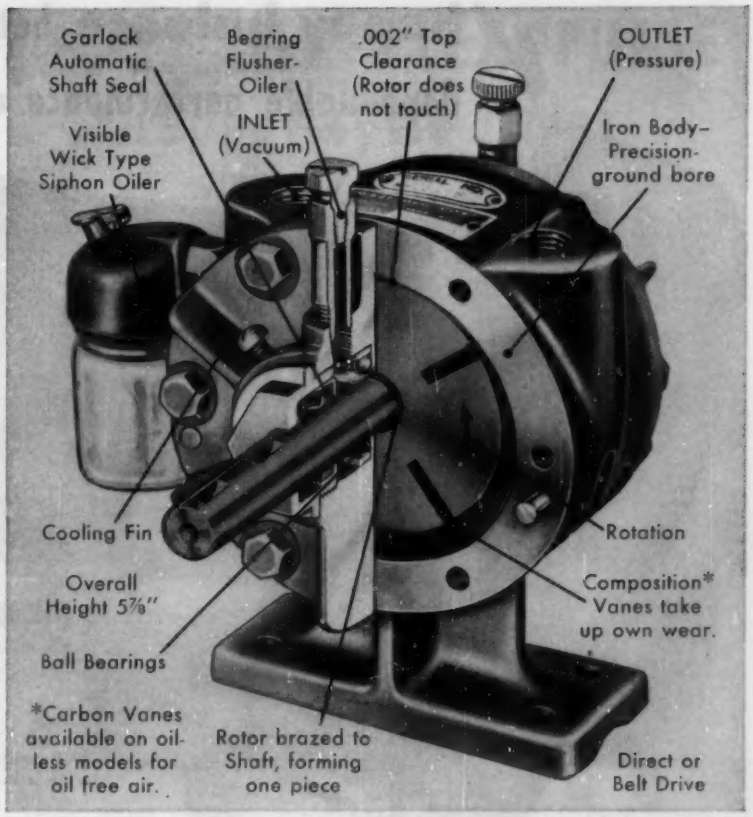
Circle 679 on page 19

Way Guards

bellows-type units are custom-made



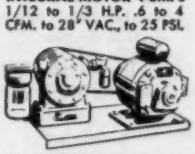
Way guards expand and compress with movement of horizontal, vertical or angular machine members. All of the folds expand equally and


Garlock Automatic Shaft Seal
Visible Wick Type Siphon Oiler
Bearing Flusher-Oiler
INLET (Vacuum)
.002" Top Clearance (Rotor does not touch)
OUTLET (Pressure)
Iron Body–Precision-ground bore
Cooling Fin
Overall Height 5⅞"
Ball Bearings
*Carbon Vanes available on oil-less models for oil free air.
Rotor brazed to Shaft, forming one piece
Rotation
Composition* Vanes take up own wear.
Direct or Belt Drive

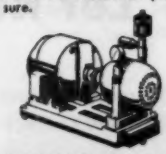
rotary vane

Quality and simplicity keep GAST AIR PUMPS operating for years at high efficiency levels

INTEGRAL-MOTOR PUMPS 1/12 to 1/3 H.P. .6 to 4 CFM. to 28" VAC., to 25 PSI.



LIGHT-DUTY PUMPS, V-belt or direct drive. 2 to 24 CFM. Moderate vacuum or pressure.



HEAVY-DUTY PUMPS, 1/4 to 1-1/2 H.P. 4 to 21 CFM. To 28" VAC. or 30 PSI. Cooling fans and fins.

As original components—or for special plant use—Gast Air Pumps offer important advantages. This cutaway reveals many reasons why they are specified as "original equipment" by more and more leading manufacturers.

All models are built to high quality-precision standards in a new, modern plant. All embody this inherently efficient, simple rotary-vane design. Balanced rotor is free of vibration. Sliding vanes are light in weight—for minimum motion-energy-friction loss compared to other pump designs. As vanes take up their own wear automatically, pump delivers full performance through years of use.

Get full details—write for *"Application Ideas" Booklet and Catalog.* Many sizes—*mention capacity and type that interests you!* Gast Manufacturing Corp., P. O. Box 117-P, Benton Harbor, Michigan.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

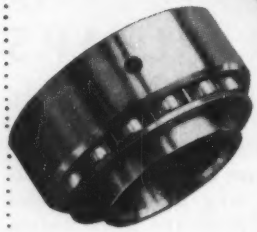
Circle 510 on page 19

✓ happy balance between dependable performance and moderate cost

Tru-Rol *precision, steel-cage, heavy-duty bearing with contoured guide lips assuring true right-line rolling, maintained roller alignment and thin oil film.*

● Rollway's *TRU-ROL* Steel-Cage Bearings afford wide latitude in balancing *dependable* performance, *long* life, and *high load* capacity against *moderate* cost. They rate high in any comparison on a cost-performance basis.

A choice of stamped steel retainers with contoured guide lips, or steel segmented retainers assure true rolling and an evenly distributed *thin* oil film — *big factors in reducing power losses and heating.*



TYPE D

Rollway Metric Series Steel Cage Roller Bearings

● Rollway Metric Series Steel-Cage Bearings offer the greater load capacity of solid cylindrical rollers, plus the true right-line rolling of trunnion rollers turning in a rigid steel cage. There's no roller skew, no pinch out, no cam action. Design permits maximum bearing capacity . . . within small space . . . at moderate cost.

"Crowned" Rollers Relieve End Stress

TRU-ROL offers the extra advantage of a finish-ground "crown" radius on the roller ends. That relieves high end-stress and insures uniform load distribution over the entire length of the roller. The result: *TRU-ROL* Steel Cage Bearings carry heavier loads over longer periods without excessive end-fatigue. They are less affected by slight misalignment or shaft deflection.

Investigate *TRU-ROL* Steel Cage Roller Bearings before selecting any bearing in the medium price range.

Let Rollway Help...

Our complete engineering and metallurgical services will gladly work with you on your problem. Simply write or wire any sales office. No cost. No obligation.

Rollway Bearing replacements are available through authorized distributors in principal cities. Consult your classified phone directory.

ROLLWAY BEARING CO., INC. SYRACUSE, N.Y.

ROLLWAY BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Milwaukee • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

simultaneously, insuring long life and complete protection. Oil and heat-resistant flexible neoprene is used as the basic material to provide protection against oil, dirt, hot chips and falling objects. Guards are custom designed to fit customer's application. **Can-Pro Corp.**, Dept. MD, 19-23-31 E. McWilliams St., Fond du Lac, Wis.

Circle 680 on page 19

Linen Spur Gears

miniature units in pitches from 48 to 96

Precision phenolic-resin impregnated linen spur gears are available in pitches of 48, 64, 72 and 96. Bore sizes are ⅛, 3/16, and ¼-in.,

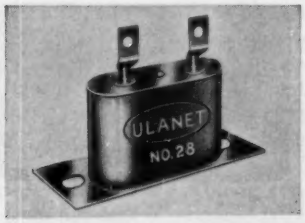
and face widths are ⅛ and 3/16-in. Gears are cut to AGMA Precision Class 1. Material meets MIL-P-15035 type FBL and is treated with fungus-proofing varnish before tooth cutting. **PIC Design Corp.**, 160 Atlantic Ave., Lynbrook, N. Y.

Circle 681 on page 19

Miniature Thermostat

has high stability and rapid response

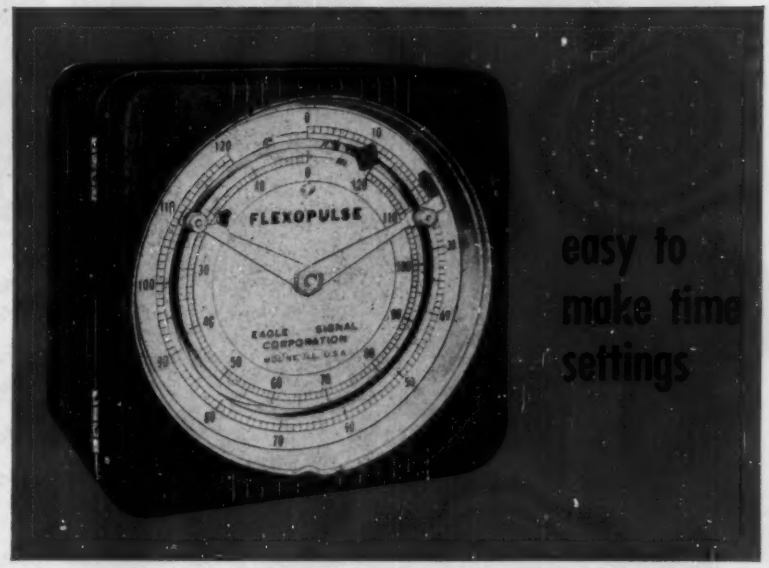
Hermetically-sealed, surface-sensing miniature thermostat, which meets stringent military aircraft applications, shows high stability and rapid temperature response. Design shortens the heat path be-



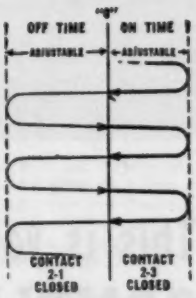
tween mounting surface and thermal-sensing element to decrease response time. Units are precali-

EAGLE FLEXOPULSE repeat cycle timer

WITH S.P.D.T. SWITCH



No gear change or resetting of cams required



This Flexopulse Repeat Cycle Timer is ideal for controlling processing machines requiring adjustable timed cycles. The "on" or "off" intervals are easily adjusted. Either can be adjusted without disturbing the setting of the other. Instead of resetting cams or changing gears, simply loosen two knurled nuts. Then set "on" and "off" periods by moving adjustable pointer. Tighten screws, and the job's done.

HAS CYCLE PROGRESS INDICATION:

A movable flag indicator passing over the time scale between adjustable arms, indicates portion of cycle elapsed in either of the s.p.d.t. positions. Switching operation takes place at zero.

Flexopulse is ideal for periodically operating valves to reverse the flow of liquids, for operating signals or for injecting chemicals. 120-second up to 20-hour dials are available. Synchronous motor powered. Send coupon today for free Bulletin 320.

FREE BULLETIN, MAIL COUPON

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. MD-157
MOLINE, ILLINOIS

Please send free Bulletin 320 with full data on Flexopulse Repeat Cycle Timer.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

Circle 512 on page 19

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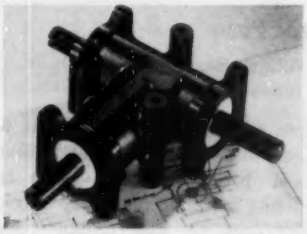
brated to specified temperature, and adjustment screw is sealed. Strain-relief construction prevents calibration drift when unit is subjected to temperature variation between −50 and 200 C. Thermostat is 5/16-in. wide, 7/16-in. high (exclusive of terminals), and ¾-in. long. Ratings are: 5 amp, 28 v dc noninductive load; 5 amp, 115 v ac. **George Ulanet Co.**, 425 Market St., Newark 5, N. Y.

Circle 682 on page 19

Angle-Gear Unit

is available with capacity to 5 hp

Angle gear unit is available with two or three shaft extensions, ratios of 1:1 and 2:1 and power capacities of ½, 1, and 5 hp. Unit has Coniflex bevel gear teeth with



self-adjusting feature for smooth operation and even load distribution and has both end and three-bolt side mounting. Overall size of 5 hp unit is 12 by 11¼ by 4 in. including 1 in. diam shafts. **Airborne Accessories Corp.**, 1414 Chestnut St., Hillside, N. J.

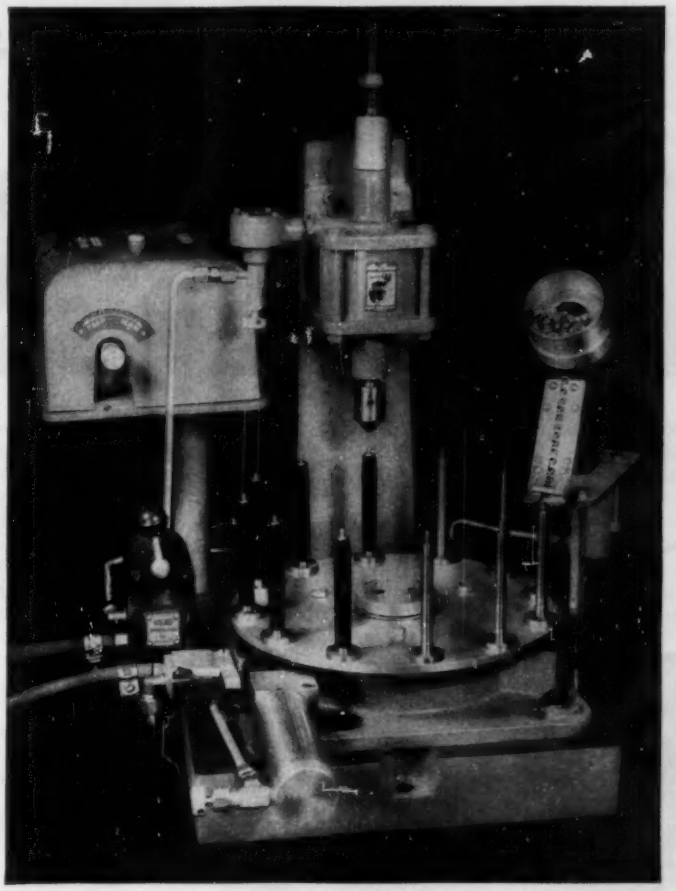
Circle 683 on page 19

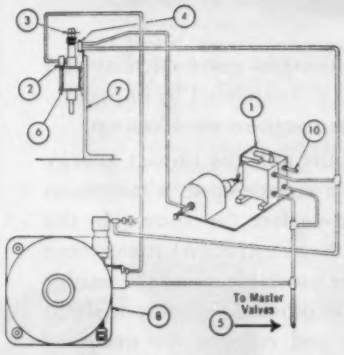
Time Delay Relay

has delay periods from 0.1 to 5.0 seconds

This miniature time delay relay is designed for application in aircraft or missile instruments and controls, automation circuits, electronic computers, communications equipment and other systems requiring precise time delay control. Models are available with delay periods from 0.1 to 5.0 seconds. Units measure 1 x 1 x 1½ in. and weigh less than 2 oz. Timing control is 10 per cent of nominal from −55 to 125 C with input voltage variations of 10 per cent. Both dc and ac models are offered, with

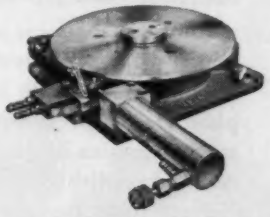
Automation With Air Power





Circuit Diagram of Units in This Photo
Combine readily to feed work to drill press, air impact hammer for a wide variety of operations.

MEAD Rotary Work Feeder is the heart of this machine to crimp eyelets and rings on pen barrels. A simple combination of standard Mead units makes a semi-automatic machine—operator merely loads.



The ROTARY WORK FEEDER Indexes to 8, 12 or 24 stations, at speeds from 15 to 150 stations per minute. Auxiliary valve actuates drill press feed or other pneumatic tool as each station indexes.

(1) Meadmatic Timer controls cycles per minute and "dwell" (2) Speed control valve and quick exhaust valve regulate advance and retraction of tool. (3) Adjustable depth stop. (6) Single-acting air cylinder. (7) Vertical stand. (8) Rotary Work Feeder. All units mounted on Universal Base.

MEAD

Write for free booklet of 44 "Examples in Air Power Automation."

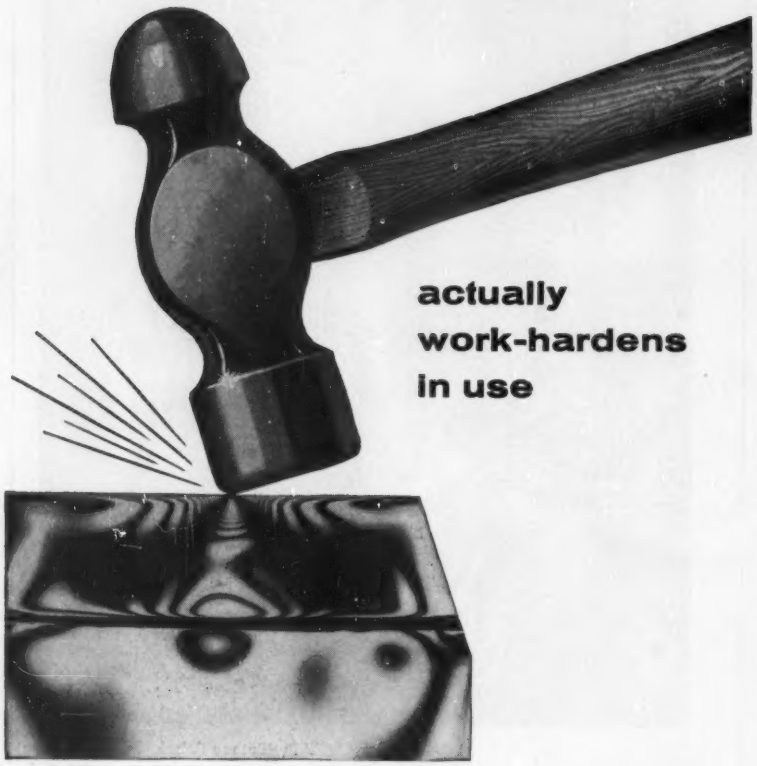
SPECIALTIES COMPANY, 4114 N. Knox, Dept. MD-17, Chicago 41, Ill.

PATHFINDER IN AIR POWER AUTOMATION

Circle 514 on page 19

AMSCO®
MANGANESE STEEL

absorbs impact energy...



actually work-hardens in use

If you require steel with high strength, good ductility and excellent resistance to abrasion accompanied by impact... use Amsco manganese steel, the toughest steel known.

Amsco manganese steel actually absorbs impact energy which work-hardens the metal's surface up to a maximum of 550 BHN, while below the surface (as shown by the photoelastic stress pattern in the illustration) manganese steel maintains its ductility. The more it's used, the harder and more polished the surface becomes. This self-polishing characteristic minimizes wear and reduces the need for frequent lubrication.

For a complete discussion of its technical aspects and inherent design features, send for your *free* copy of the Amsco booklet, *Austenitic Manganese Steel.*

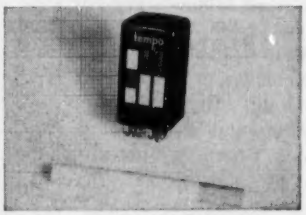
AMERICAN MANGANESE STEEL DIVISION

AMERICAN Brake Shoe COMPANY

Chicago Heights, Ill.

New Parts

inputs from 28 to 150 v dc and from 26 to 115 v ac at 60 to 400 cps. Internal relay arrangement is DPDT, with contact rating of 2



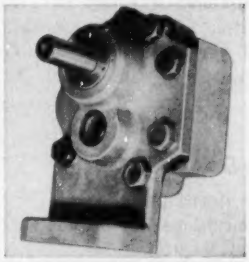
amp resistive. Desired time delay occurs after application. Unit is vibrationproof to 15 g and 500 cps. Entire unit is hermetically sealed and is available with miniature plug-in base, solder terminals or pig-tail leads. **Tempo Instrument Co.,** 5 Centre St., Hempstead, N. Y.

Circle 684 on page 19

Gear Pump

unique design for mass-produced units

Simple, economical gear pump features unique design which allows mass production of gears and housing without necessity of close tolerances or fine finish. Gears may be hobbed, rolled or made of metal powder without fine tooth finishing operations. Housing cavity may be machined or left as die-



cast because peripheral clearance does not affect performance of pump. A synthetic rubber pad conforms to gear teeth along pressure outlet side of pump. Calibrated spring under pad acts as relief valve for any established maximum pressure. Output raises slightly as fluid temperature rises. Flow range is nearly independent of pressure at any selected speed. **New Products Corp.,** 3636 Oakton St., Skokie, Ill.

Circle 685 on page 19

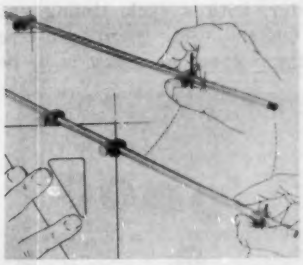
ENGINEERING DEPARTMENT

EQUIPMENT

Ellipsograph

is formed by adding extra block to compass

Beam compass is easily converted to an ellipsograph which draws ellipses with any axis length from 7/16-in. to 12 in. and to any de-



gree of plane rotation from 10 to 65. Beam compass draws 24 in. diam circles and is converted to ellipsograph by changing points and adding a third block. Instrument is polished aluminum. **Aero Engineering Sales Co.,** Box 85, Azusa, Calif.

Circle 686 on page 19

Pressure Pickup

for dynamic pressures from 10^{-4} to 100 psig

Dynamic pressure pickup measures dynamic pressures consisting of complex waves from sonic vibration, blast pressures, or water-hammer of liquid-filled lines. Pressure applied to diaphragm of

sealed, liquid-filled cell causes infinitesimal amount of polar liquid to flow through porous disk, generating electrical signal. Pickup will operate at pressure range of 10^{-4} to 100 psig and temperature

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Kwik Mix, Port Washington, Wis. • *Concrete Buggy*
Crescent Pump Co., Rockland, Mass. • *Diaphram Pump*
Wald Industries, Inc., Huntingdon, Pa. • *Highway Line Marker*
E. R. Brenholts, Gerard, Pennsylvania • *Road Grader*
Atwater Strong Company, Atwater, Ohio • *Air Sweeper*
Meade Products Mfg. Co., Meade, Kansas • *Riding Lawn Mower*
Hansen Equipment Co., Beloit, Wis. • *Chemical Farm Sprayer*
Minn-Kota Manufacturing Co., Moorhead, Minn. • *Grain Swather*
O. W. Kromer Company, Minneapolis, Minn. • *High Clearance Sprayer*
Franklyn Products, Milwaukee, Wis. • *Portable Mink Feeder*
Phillips Conveyor Company, Memphis, Mo. • *Coal Conveyor*

K90—1.8 to 3.6 H.P. K160—3.7 to 6.6 H.P. K330—8.2 to 12.5 H.P. K660—15 to 26.8 H.P. (2 cylinder opposed)

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133 Sidney Street, Cambridge 39 Massachusetts

Engineering Equipment

range −10 to +140 F. Flat response between 3 and 2500 cps produces electrical signals in phase with and proportional in amplitude to pressure, eliminating phase lag or over-shoot of pressure signals. **Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle 687 on page 19

Electronic Tachometer

reads speeds of 0 to 60,000 rpm

Electronic tachometer is basically a four-digit glow transfer-tube counter, with a cycle timing gate to control the count-read-reset cycling. Speed accuracy is ½ per

cent of full scale on 60-cycle supply reference. Units are available with speed ranges of 0-720 rpm, 0-7200 rpm, and 0-60,000 rpm. **Magtrol Inc.**, 38 Virginia Pl., Buffalo 2, N. Y.

Circle 688 on page 19

Digital Counter

has counting frequency of 15,000 cps

Transistorized digital counter, when teamed with appropriate conversion equipment, counts articles, distance, degrees of rotation or angular measurements at high

speeds. Counting frequency is 15,000 cps. Design incorporates transistors, printed circuit boards and modular construction. Total power consumption of the counter is 2 w; transistors operate well below their maximum rating. Input

Circle 517 on page 19

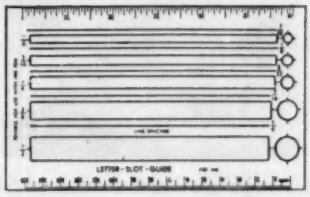
power is 60 cycle, 85 to 140 v; resolution is 10 microseconds. Unit is 4 in. high, 11⅝ in. wide, 9⅛ in. deep. Counter can be preset from 1 to 500 for batch counting. **Nader Mfg. Co.**, 2661 Myrtle Ave., Monrovia, Calif.

Circle 689 on page 19

Lettering Template

facilitates hand lettering

Lettering slot-guide template is shatterproof, transparent acrylic material, 0.060-in. thick. Template has slots 1/8, 3/16, 1/4, 3/8 and



1/2-in. wide and is designed to give unlimited choice of lettering or numbering in slanted, broad or narrow characters. **Alvin & Co.**, Windsor, Conn.

Circle 690 on page 19

Vibrometer

measures from housing or rotating shaft

Vibrometer, which has an integral probe, measures vibration amplitude on machine structures or di-

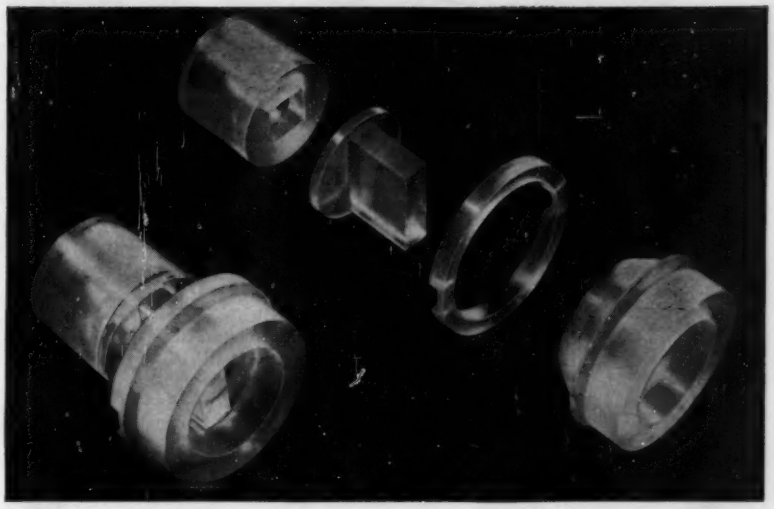
rectly on surfaces of rotating shafts. Indication is a band of light on graduated, ground-glass scale. **Vibroscope Co.**, Box 97, Glenford, N. Y.

Circle 691 on page 19

Servo Dynamometer

tests motors with servo-mountings

HDE-100 servo Dynamometer has hysteresis brake to accurately absorb motor power so that running



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Machine that part from polystyrene and let us investment-cast it in the metal you plan to use. Test it and, if some change is indicated, repeat the process until you have the final answer. This cut-and-try method of proving a design and an alloy saves you a lot of time and money.

Polystyrene machines readily and is inexpensive. Complex patterns can be made in sections and assembled, then cast as a unit just as they'd be investment-cast in quantity. Thus parts for testing are exactly like you'll get in production, but they cost far less than cutting them out of metal.

Technical Data Available

When your idea is on paper, but before you start to make the polystyrene patterns, send us a blueprint. We'll figure the shrinkage factor for you, suggest possible gating arrangements and design modifications which may effect further economies.

The pamphlet, *A Guide for Making Polystyrene Patterns*, describes methods of machining and names sources from which this material can be obtained. For a free copy, write Precision Metalsmiths, Inc., 1083 East 200th Street, Cleveland 17, Ohio.

pour yourself an assembly with

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Investment Castings

Circle 518 on page 19

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Circle 519 on page 19

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Circle 520 on page 19

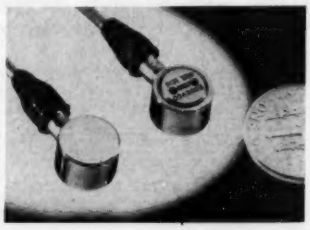
Engineering Equipment

torque of test motor is balanced against swing of a calibrated pendulum weight. Motor can be tested for free-running, load and stall characteristics. When used with tachometer, unit will indicate motor speeds up to 60,000 rpm. **Magtrol Inc.**, 38 Virginia Place, Buffalo 2, N. Y.

Circle 692 on page 19

Turbulence Gage

is 3/8-in. diam by ¼-in. thick

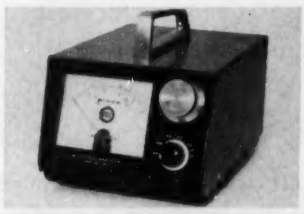


Unit measures turbulent pressures in wind tunnels, on skin surfaces of models, and can be used for study of fluid flow in gas and hydraulic lines. Gage provides 40 mv sensitivity per psi within pressure range of 0 to 10 psi. Natural frequency is over 50 kc; frequency range is ±5 per cent from 2 cps to 10,000 cps. **Endevco Corp.**, 161 E. California St., Pasadena, Calif.

Circle 693 on page 19

Moisture Detector

measures moisture in gases to 1 ppm



Portable, dependable instrument is for accurately measuring minute quantities of moisture in a gaseous mixture. Unit will measure water content accurately down to 1 part per million and permits precise meter readings over full-scale range of 0 to 1000 ppm. Monitor operates on 50/60 cycle, 105/125 v ac current. **Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle 694 on page 19

Stress Relief

HERE'S an unusual viewpoint, by J. P. Henderson, of course, on the "practical" versus the "theoretical," or

Joe Tinker and the Mathematician

I've been talking to a man again, and sure enough I've learned of a few more worries that beset the technical executive. This particular trouble befell a chief engineer, and here is his tale, pretty much in his own words.

"As you know, J. P., we make electrical equipment, and included on my staff are some sharp engineers with excellent mathematical background. I also have some gadget men. 'Joe Tinkers,' I call them.

"Both are useful and necessary. But every now and then Tinker comes out with a good idea, a gadget, or a modified construction, useful and clever. In the course of time, the management sees it, and the president especially gets intrigued by stuff of that sort.

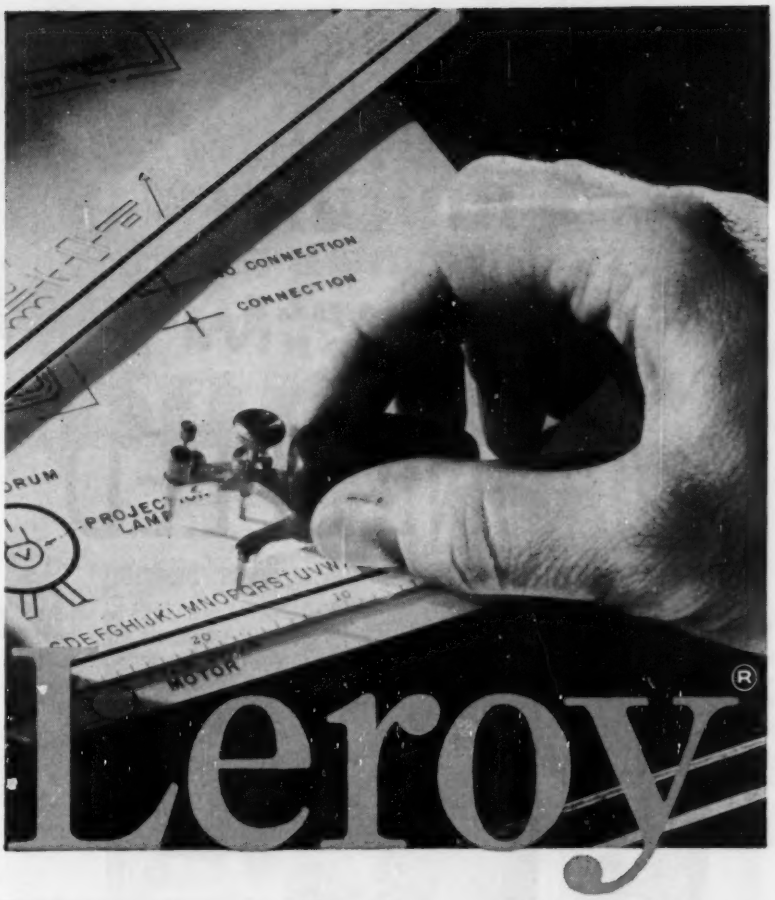
"Gadgets are particularly fascinating to the lay mind. Every time this lawyer-president sees something of that sort he is loud in his praise of Tinker.

"Why don't I promote a man like that? Am I sure I am paying him enough money? He surely is a clever one—we ought to have more like him in our organization.

"All well and good. I'm not belittling Joe Tinker. He *does* do a good job for us. But I have to keep things in balance.

"Last month one of my high-powered designers made a fine analysis of a technical problem, using some smart mathematics. As a result, we can build some of our equipment with less material, and feel more sure of what we are going to have when a job is completed. It will enable us to predict some special jobs for Sales or prospective customers with fair certainty, fewer samples, less expense.

"To a greater or lesser degree,



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Circle 521 on page 19

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*Trade Name

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Stress Relief

on that problem (or others like it) my high-powered technical men have done excellently.

"But how do you glamorize that to a lawyer? It's work that intrigues an engineer but when I try to explain to the rest of management the importance of such developments, they are obviously bored. They believe me, in an abstract way, but they are not interested.

"It's useless to show them a dozen pages of formulas. They are pleased to know that time and money can be saved as a result, but it seems rather nebulous.

"But give them a gadget, and Joe Tinker is a hero.

"A highly technical man, dealing largely with mathematics, should realize that he has a handicap. His work may not be understood and hence not appreciated by many persons above him in an organization. He'd better check himself and develop some personal salesmanship.

"Also it's up to his supervisor to help build up this type if he expects to get them money and advancement."

All of this fits very nicely with some comments I quoted a few months ago about large organizations versus small.

It's only in a small or medium-sized organization that nontechnical leadership can reach down ineptly to influence the fate of Joe Tinker versus the mathematician. It can form an extra hazard in attracting the highest grade technical man to the small company.

In a large organization there are usually enough technical men in the intervening steps on the ladder to see that technical virtue gets its reward.

Well, almost.

—J. P. HENDERSON

They Say . . .

"Common sense is chiefly integrity plus energy; it is the ability and the will to sort out the relevant from the muck of the plausible which convention automatically piles up around all things."—JACQUES BARZUN

THE ENGINEER'S Library

Recent Books

Aircraft Materials and Processes. *By George F. Titterton, assistant chief engineer, Grumman Aircraft Corp.; 398 pages, 6 by 9 in., clothbound; published by Pitman Publishing Corp., 2 West 45th St., New York 36; available from* MACHINE DESIGN, *$6.00 postpaid.*

This fifth edition is general in scope and includes definitions of terms, testing of aircraft materials, steel and its alloys, properties and uses of aircraft steels, heat treatment, surface hardening, shaping of metal (both hot and cold), properties of corrosion-resisting steels, copper and alloys, aluminum and alloys, magnesium, wood, glue, fabric, plastic, rubber, titanium, and the selection of materials for various applications.

Lefax Engineering Formulas and Tables. *396 pages, 4 by 7 in., paperbound, two-pin binder; published by and available from Lefax, Sheridan Bldg., 9th and Sansom Sts., Philadelphia 7, Pa.; $2.75 per copy.*

This loose-leaf reference manual contains basic formulas, design data and tables for civil, mechanical and electrical engineers. Included are mathematics, measure, materials, gages, mechanics, electricity and magnetism, hydraulics and mathematical tables of logarithms and trigonometric functions.

The Light Metals Handbook. *By George A. Pagonis, Light Metals Research Laboratory, San Jose, Calif.; 2 volumes, 432 pages, 6 by 9 in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, *$9.50 postpaid.*

Volume I of this two-volume set is divided into two parts. Part 1 treats magnesium and magnesium-base alloys. Classes of material are discussed as are mechanical properties, including high and low-temperature effects, compositions,

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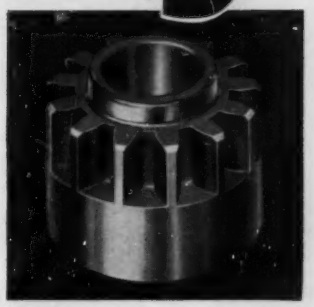

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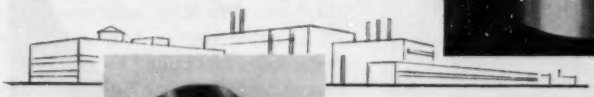

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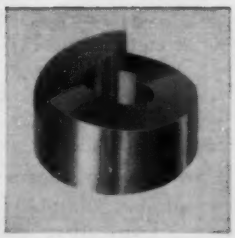

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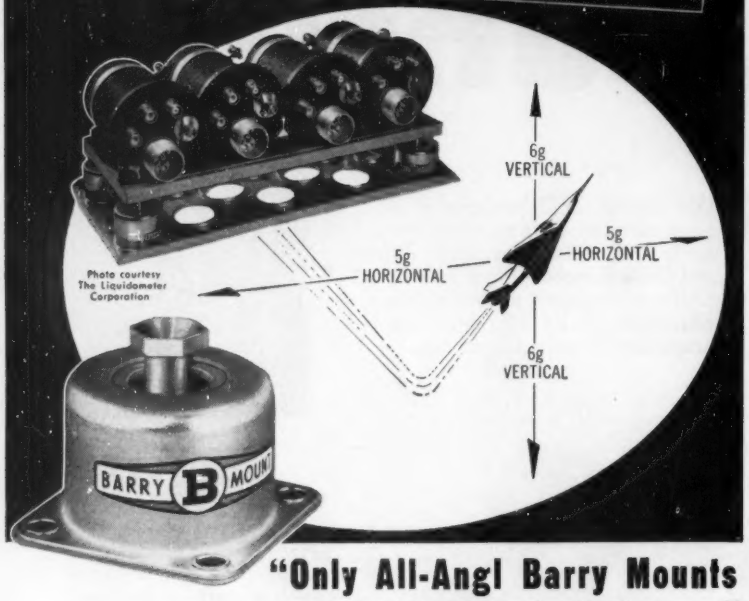

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selection of alloys, casting characteristics, formability, corrosion, and joining methods. Part 2 gives a similar treatment for Aluminum and its alloys. Volume II consists of 93 tables on the properties of magnesium and 138 tables on aluminum.

How to Find a Buyer for Your Invention. *By V. D. Angerman; 186 pages, 5½ by 7 in., clothbound; published by and available from Science and Mechanics Publishing Co., 450 E. Ohio St., Chicago 11, Ill., $2.95 per copy.*

This interesting book explains in detail the process of evaluating, patenting, and marketing an invention. Advantages of patent brokers, sales agents, and selling services are explained. A listing of manufacturers interested in patented inventions is included.

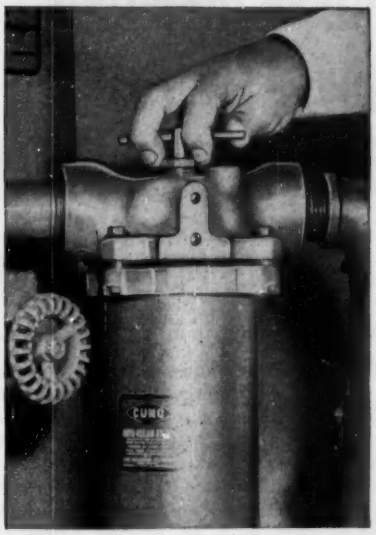
Materials of Engineering. *By Carl A. Keyser, professor of metallurgical engineering, University of Massachusetts; 502 pages, 6 by 8½ in., clothbound; published by Prentice-Hall Inc., 70 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$8.00 postpaid.*

This book presents information on the most important properties of materials, with details of fabricating technique and methods of testing. The book is divided into three parts: metallic materials, inorganic nonmetallic materials, and organic materials. Materials treated include base metals, alloys, minerals, concrete, plastic, rubber, wood and coatings. Limitations imposed upon processing methods by properties of material selected are pointed out. Also discussed is the effect of different processing methods upon service properties of materials.

National Standards in a Modern Economy. *Edited by Dickson Reck, late professor, School of Business Administration, University of California, Berkeley; 372 pages, 6 by 9 in., clothbound; published by Harper & Brothers, 49 E. 33rd St., New York 16, N. Y.; available from* MACHINE DESIGN, *$5.00 per copy.*

A collection of works by 34 noted authorities, this book is both a review of the evolution of standards and an evaluation of their

FILTRATION NEWS



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Circle 525 on page 19

Library

place today. The book considers the legal aspects of standards, their relation to industrial self-government, and their effect upon individual enterprise and the economy as a whole.

Magnetic Materials in Electrical Industry. *By P. R. Bardell; 288 pages, 5½ by 8½ in., clothbound; published by Philosophical Library Inc., 15 E. 40th St., New York 16, N. Y.; available from* MACHINE DESIGN, *$10.00 per copy.*

This book is intended for senior students in physics and electrical engineering and for physicists and engineers in industry. Its primary purpose is to link the properties of magnetic materials with their applications. Included are a glossary of terms, units, and trade names of materials, tables of properties, and an explanation of magnetic terminology and units. Also covered are application and testing of permanent magnets and soft magnetic materials, and a treatment of devices such as sound recorders, testers, transductors and transducers.

Foundry Practices. *By S. E. Rusinoff, professor of mechanical engineering and manufacturing processes, Illinois Institute of Technology; 261 pages, 5½ by 8 in., clothbound; published by American Technical Society, 848 E. 58th St., Chicago 37, Ill.; available from* MACHINE DESIGN, *$6.50 postpaid.*

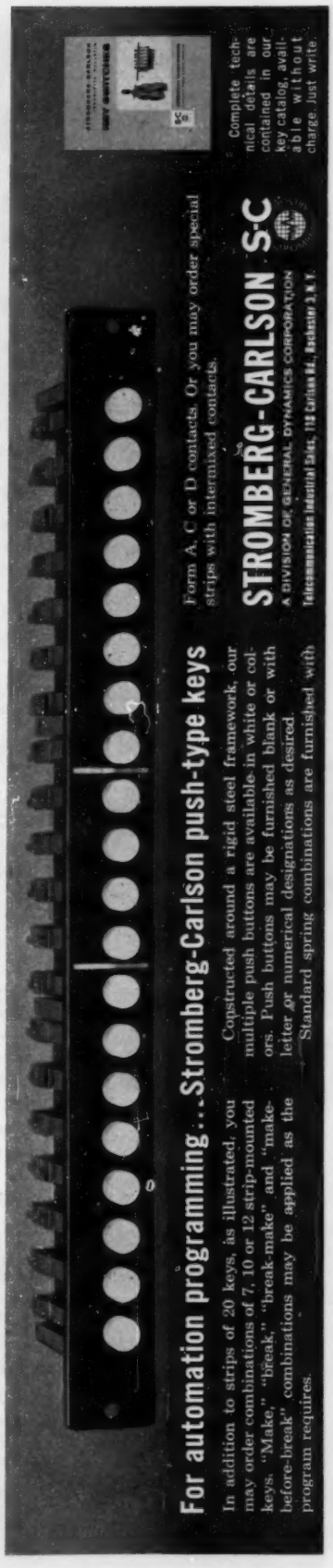
Metal casting and foundry practice are discussed in this text. Contents include casting processes, patterns, sand-molding and core-making, and melting furnaces. The metallurgy of cast metals and testing procedures are covered.

New Standards

Selected ASTM Engineering Materials Standards. *370 pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.00 per copy, $1.50 to students of engineering colleges.*

Primarily intended for use in engineering curricula, this compilation includes standards and specifications for frequently used engineer-

(*Continued on Page 202*)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Circle 526 on page 19

Copyflex Machines and Sensitized Materials

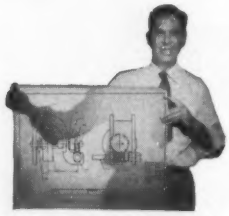
ADD MANPOWER TO YOUR DRAFTING ROOM

Modern Reproduction Machines, Materials, and Techniques Cut

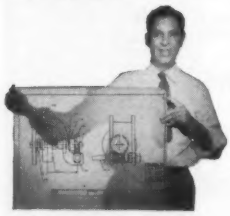
The boom in production means more pressure than ever for engineering prints and drawings. Now, more than ever, is the time to (1) replace that old, inadequate reproduction unit with a modern, efficient Copyflex machine and (2) capitalize on the many drafting shortcuts made possible by Copyflex reproduction machines and sensitized materials.

Six New, Advanced Machines: In just the past 18 months Bruning has introduced six new, greatly improved models—five of which are shown at right. They bring you not only faster reproduction but a host of design improvements that will boost your drafting room output sharply. One of these six new machines will surely meet your exact requirements.

Slash Re-Drafting Time: Your Copyflex machine is more than a means of making conventional opaque prints of finished drawings—it can also help you in your actual drafting operations. In many cases involving the re-working of existing drawings, for instance, it can save you up to 90% in tracing time through the use of translucent prints ("intermediates") made on film, cloth, or low-cost paper. Consider how much of your drafting is devoted to design changes, changes in standards, and similar alterations and you'll see why adding Copyflex to your production team will *add manpower to your drafting room.*



This design change took hours to make because it was done entirely at the drawing board.



The same design change was completed in less than an hour with the aid of a Copyflex intermediate.

These Materials Speed Reproduction *and* Drafting

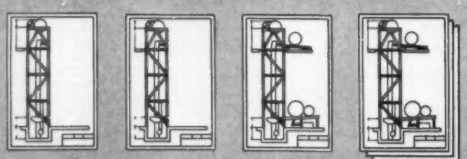
Copyflex Translucent Sensitized Paper: Prints made on this 100% rag, resin-transparentized medium provide: (1) a positive, reproducible image of all or any selected part of an original; (2) a workable drawing surface for making additions or alterations; and (3) excellent translucency for making fast, sharp reproductions. In the making of design changes, prints made on this paper eliminate the need for tracing those sections of the design which do not require alteration. Unwanted portions can either be masked out in the printing operation or eradicated on the translucent print . . . then new lines added. The paper prints accept pencil and ink, and drawn lines are erasable. Subsequent alterations are achieved just as easily and quickly by use of the same reproduction-drafting technique.

Copyflex Sensitized Matte Film: Usable for same purposes as Copyflex Translucent Sensitized Paper, but is highly transparent and much more durable. Reproduces faster than originals made on tracing paper.

Copyflex Sensitized Clear Film: Offers complete transparency and extremely fast reproduction speed. Not suitable for drawing, but ideal for making composite prints, overlays, and projection prints. Various developers can be applied to it to produce different color effects.

Copyflex Sensitized Tracing Cloth: A top quality moisture repellent cloth with excellent pencil and ink workability. The ideal material to use when circumstances require a translucent print with exceptional durability and strength.

HOW COPYFLEX SPEEDS DESIGN CHANGES

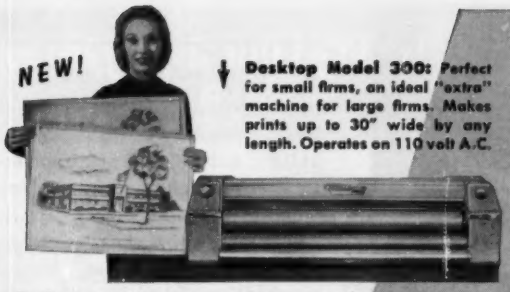

Original Drawing
Translucent Print of Original
Print with Alterations Drawn In
Prints Made from Altered Intermediate

Problem: To make a design change without marking or altering the original drawing or tracing.

Old Method: (1) Trace unchanged parts of the original by hand; (2) draw in the design changes or alterations.

Copyflex Method: (1) Reproduce unchanged parts of the original in a matter of seconds on Copyflex translucent paper, cloth, or film—blocking out or later eradicating any unwanted portions of the original design; (2) draw in the design changes or alterations.

Result: Substantial savings in time, money, and drafting room manpower.



NEW!

Desktop Model 300: Perfect for small firms, an ideal "extra" machine for large firms. Makes prints up to 30" wide by any length. Operates on 110 volt A.C.

Drafting Time, Boost Productivity!

NEW!

Model 500: A heavy-volume machine offering top mechanical speed of 40 f.p.m., 46" printing width, automatic separation and stacking, front or rear delivery, and many other advanced features.

Model 250: Takes less than a sq. yd. of floor space. Has top mechanical speed of 25 f.p.m., 18½" printing width, automatic separation and stacking. Operates on 220 volt A.C.

Model 200: A 110 volt A.C. version of the Model 250.

NEW!

NEW!

Model 35: Provides up to 30 f.p.m. mechanical speed and a full 46" print-width for heavy volume reproduction at a thrifty, low cost.

Model 20: Not a new model, but a dependable performer well worth your consideration. Makes prints up to 46" wide. Operates on 110 volt A.C.

Model 30: A faster, 220-volt version of the Model 20.

Desktop Model 110: A new and improved small machine with 11" printing width. Makes 8½"x11" prints for less than 1¢ each for materials. The helper your big machine needs!

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and sensitized materials:_____

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Company_____

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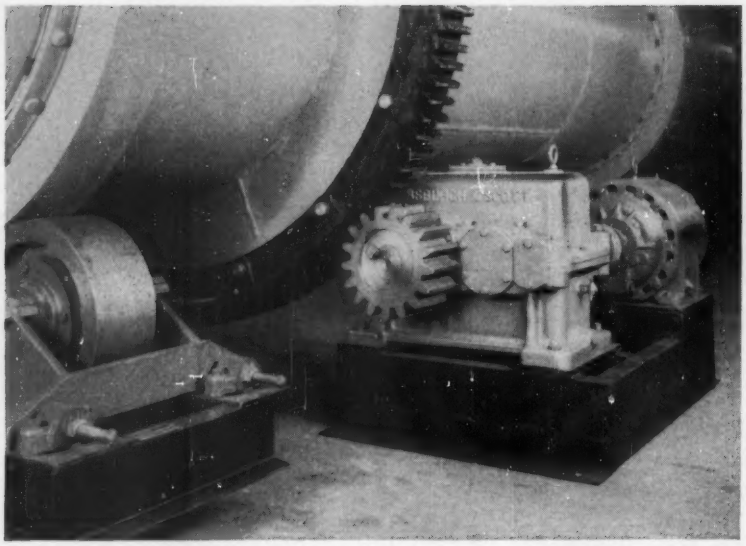

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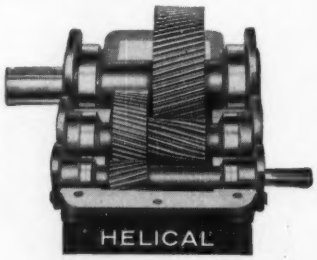
H&S Herringbone, Helical and Worm Gear Speed Reducers have been serving heavy industry for 26 years. If you are looking for dependable, trouble-free power transmission, won't you contact your H&S representative or write us today?

H&S Reducers are available in single reduction units in ratios up to 100 to 1; in combination units up to 700 to 1; and in double reduction units up to 10,000 to 1.



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Library

(*Continued from Page* 199)

ing materials and the testing methods. Included are data on the availability, nature, and origin of specifications for engineering materials.

Retaining Ring Standards. 10 *pages,* 8½ *by* 11 *in., loose, three-hole punched; published by and available from National Standards Association,* 616 *Washington Loan and Trust Bldg., Washington* 4, *D. C.;* $1.00 *per set.*

These new standards cover both external and internal retaining rings. Information includes groove dimensions, inspection techniques, limit loads and deflection under loads, installation methods and standard dimensions.

Manufacturers' Publications

Magnetrons and Traveling-Wave Tubes. 37 *pages,* 8½ *by* 11 *in., paperbound; published by and available from Commercial Engineering, RCA Tube Div., Harrison, N. J.;* $0.50 *per copy.*

This booklet contains basic information on the features and applications of these micro-wave devices. Described are the theory of operation of magnetrons and traveling-wave tubes, operating considerations and applications, and techniques for measurement of important electrical parameters.

Government Publications

NACA Technical Series. Each publication is 8 by 10½ in., paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics, 1924 F St. N.W., Washington 25, D. C.

The following Technical Memorandums are available:

1425. On the Calculation of Shallow Shells—11 pages.

1426. On the Theory of Thin Shallow Shells—7 pages.

The following Technical Notes are available:

3832. On Possible Similarity Solutions for Three-Dimensional Incompressible Laminar Boundary Layers, II—Similarity with Respect to Stationary Polar Coordinates—16 pages.

3851. Failure Characteristics of Pressurized Stiffened Cylinders—18 pages.

3853. Compressive Stress-Strain Properties of 2024-T3 Aluminum-Alloy Sheet at Elevated Temperatures—66 pages.

3854. Compressive Stress-Strain Properties of 7075-T6 Aluminum-Alloy Sheet at Elevated Temperatures—54 pages.

ENGINEERING BULLETIN
ON MICRO BEARINGS
Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH 1, NEW HAMPSHIRE

Subject: DYNAMIC AND STATIC LOAD RATINGS

DYNAMIC LOAD RATINGS

Load ratings of MICRO bearings are based on standards established by the Anti-Friction Bearing Manufacturers Association and are the result of extensive tests.

The "life" of an individual bearing is defined as the number of revolutions which the bearing makes before the first evidence of fatigue develops. Fatigue, in turn, is a function of bearing load and although other factors, such as contamination and high temperature, affect the life of a bearing, it is assumed that clean bearings running at normal temperatures are being considered.

It is not possible to predict the life of any individual bearing. The problem, therefore, is best approached by a consideration of empirically derived dispersion curves which provide a means of determining bearing life on a probability basis. That is, they permit the average life of a given group of bearings to be accurately specified.

For purposes of standardization, the "rating life" of a group of apparently identical ball bearings is defined as the number of revolutions that 90% of the group will complete or exceed before the first evidence of fatigue develops. This figure is approximately one-fifth of the average life.

If two groups of similar bearings are run under different loads F_1 and F_2 within the normal operating range of loading and rpm, their lives L_1 and L_2 are inversely proportional to the cubes of the loads, i.e.,

$$\frac{L_1}{L_2} = \left(\frac{F_2}{F_1}\right)^3$$

The BASIC LOAD RATING C is that radial load which a group of apparently identical bearings can endure for a rating life of one million revolutions, with stationary load and rotating inner ring. Within normal operating ranges the rating life for any load *is a constant number of revolutions*, so the following relationship, a restatement of the inverse cube proportion, may be used to compute rating life when basic load rating and applied radial load are known:

$$L = \left(\frac{C}{P}\right)^3$$

L = rating life in millions of revolutions
where, C = basic load rating in pounds
P = applied radial load in pounds

The nomograph illustrated permits the quick evaluation of any one of the three quantities when the other two are known. For example, if the C rating of a given bearing is 95 pounds, and the bearing is loaded radially with 12 pounds, P, a straightedge crossing these two values in their respective columns shows that the bearing could be expected to have a life, L, of 450 million revolutions.

DEFINITION OF EQUIVALENT LOAD

Bearings whose loads are primarily radial are usually also subjected to axial forces. When the axial component of the load is greater than a negligible value, this combined radial and thrust load may be expressed in terms of a simple radial load in order that the basic load rating C may be calculated. This simple radial load is known as the "equivalent load", which is that constant stationary radial load which, if applied to a rotating inner ring, would give the same life as that which the bearing will attain under the *actual* conditions of load and rotation.

FORMULA FOR EQUIVALENT LOAD

For conventional bearing types other than those with filling notches, the equivalent radial load is given by the maximum of the two values:

a)	$P_r = VF_r$	X is a radial factor
b)	$P_r = XVF_r + YF_a$	Y is a thrust factor
where,	V is a rotation factor	F_r is the radial load
		F_a is the thrust load

The factor e represents the ratio of $\frac{F_a}{VF_r}$ for which the two equations are equal. If the ratio of loads is such that $\frac{F_a}{VF_r} \leqq e$ then formula (a) is used: if $\frac{F_a}{VF_r} > e$ then formula (b) is used.

For inner ring rotation V = 1.0 in all cases; for outer ring rotation V = 1.2 in all cases except for self-aligning bearings, where V = 1.0. In most calculations involving MICRO bearings, the following values are sufficiently accurate: X = 0.30, Y = 1.04, and e = 0.67. In the case of self-aligning bearings, however, X = 0.40 and Y = 7.6.

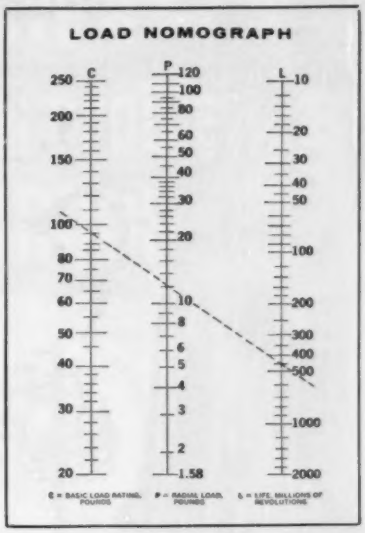
In practice, the angular contact type of bearing should not be subjected to a predominantly radial load unless opposed by another bearing.

When a bearing is loaded and at rest the dynamic life formula $\left[L_N = \left(\frac{C}{P}\right)^3\right]$ cannot be used because when $L_N = 0$ then $P = \infty$. Obviously there is a limit to the Static load which the bearing can carry, this limit being determined by permanent deformations which develop in the load carrying surfaces. Such deformations appear even under very light loads and increase gradually with increasing load, with no sharply defined limit beyond which they begin. The static load limit is dependent on the permissible magnitude of deformation, consistent with requirements of quietness and freedom from vibration. Experience indicates that a permanent deformation in the raceway of less than 0.0001 times the diameter of the rolling elements ordinarily has no objectionable influence on the functioning of the bearing.

In order to obtain an expression for the load carrying capacity at rest, and a numerical value that can be used as a reference, the pure radial load which corresponds to this negligible magnitude of permanent deformation has been selected as the basic static load rating and given the designation C_o.

If the load is much higher than C_o when the bearing is not rotating, minute depressions are formed in the raceways, causing the bearing to be noisy and to vibrate when operating at high speed, even though the bearing friction is not noticeably increased or the bearing otherwise injured. Depending on the requirements in this respect, the static load may occasionally be allowed to exceed the C_o value.

If a load considerably higher than C_o acts only while the bearing rotates, the permanent deformations that occur will be evenly distributed in the raceways and cause no serious impairment until the deformations become relatively large. However, under such a heavy load, the fatigue life will be comparatively short in terms of the number of revolutions. Static load rating values for all MICRO bearings are presented in our catalog-data book.



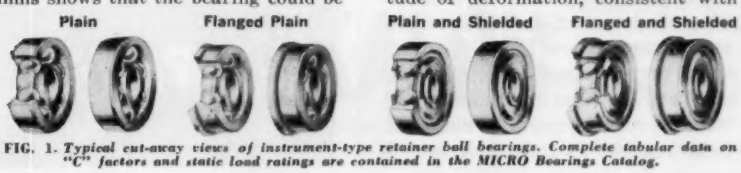


FIG. 1. *Typical cut-away views of instrument-type retainer ball bearings. Complete tabular data on "C" factors and static load ratings are contained in the MICRO Bearings Catalog.*

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Circle 529 on page 19

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WILLOW GROVE
MONTGOMERY CO., PA.

Circle 530 on page 19

New Machines

Materials Handling

Fork Truck: EUT-8024 fork truck with 8000-lb capacity is battery powered and has dual-drive wheels. Dimensional features of the machine include turning radius of 85 in.; aisle for right angle stacking of 148½ in.; and overall length of 133 in. With four speeds forward and four reverse, the truck travels loaded at 5½ mph and climbs a ten per cent grade. Power is provided by a dual-field, high-torque motor. Directional control lever on steering column controls first speed in each direction and mechanically cuts off power and locks in neutral when the operator's seat is empty. Second, third and fourth speeds are attained by a foot accelerator operating a master control switch. A switch operated by the brake pedal cuts off power to drive motor when hydraulic brakes are applied. The truck has three independent braking systems. *Clark Equipment Co., Electric Truck Section, Industrial Truck Div., Battle Creek, Mich.*

Lift Platform Truck: Electric-powered high-lift platform truck, designated E13-10, is designed for general handling operations. The 10,000-ton-capacity truck has two-wheel drive and six-wheel steer. It is hydraulically actuated, and is of end-control, stand-up, nontelescopic type. Frame is formed of heavy steel plate and electrically welded. Center-sill construction is used. All major units are attached directly to heavily reinforced alloy steel bars forming the sills. Drive motor is connected directly to the single-reduction worm and wheel with integral differential. Hydraulic lift cylinder operates the platform lift. Separate electric motor drives the pump which supplies the lift cylinder, and system operates at pressures below 12 psi. A check valve prevents sudden dropping of the load. Automatic unloading device prevents damage when platform reaches its limit of travel or

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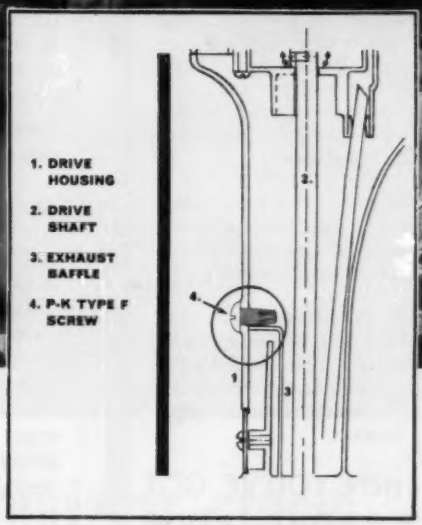
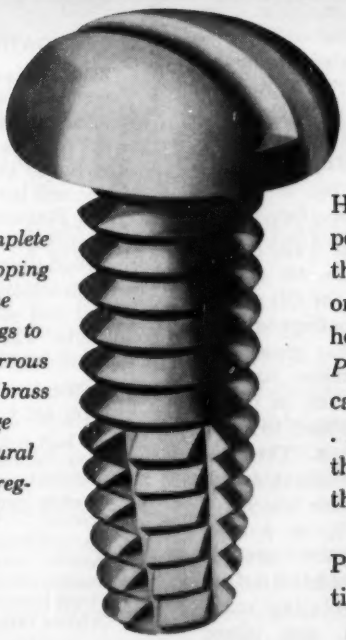
Radio

Circle 531 on page 19

how P-K® screws helped solve a design problem for EVINRUDE





Type F (one of a complete line of P-K Self-tapping Screws) used for the making of fastenings to ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steel, plastics, impregnated plywood and other materials.

How do you keep a baffle from dropping down out of position? Designers of Evinrude outboard motors found the answer. No need for an expensive tapping operation or for a complicated stamping. Simply provide a cored hole in the casting, insert the stamping and then drive a *Parker-Kalon* Type F Screw through the hole in the die-cast housing. The screw acts as a retainer for the baffle . . . and because it is a *Parker-Kalon* Self-tapping Screw, there is no chance of its loosening during the operation of the motor. Yet it can be removed, if necessary.

This application is one example of the versatility of P-K Screws which designers can employ for various functions supplementary to fastening.

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Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws

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Kokomo, Indiana

Circle 533 on page 19

New Machines

if it should strike an obstruction. *Elwell-Parker Electric Co., Cleveland.*

Metalworking

Shears: Air-operated shears cut ferrous and nonferrous strip up to 3/16-in. thick in mild steel and in widths from 24 to 84 in. They cut hot or cold carbon or stainless steel, copper, aluminum and other metals. Controls can be hand operated, foot operated, automatic, air pilot or solenoid controlled. The shears have air filter, air lubricator, muffler, self-contained hydraulic shock cylinder and set screw adjustment for bottom knife. *Curry Air Shear Corp., Pittsburgh.*

Milling Machine: Specialized milling machine, designated Radii II, cuts radii on square, rectangular, flat or round ferrous and nonferrous metals up to 1¼ in. thick and 2½ in. wide. Chips are drawn through a hollow spindle housing by means of a blower, and ejected through a chute into chip pan at the rear of the machine. Ratchet stop opposite the clamping vise allows positioning the work endwise, and is graduated in increments of 1/32-in. Stock stop is provided at the rear of the machine table. Motor is 1 hp, 3 phase, 60 cycle, 220/440 volt. Height of the machine is 39 in. *Special Machinery Co. Inc., Winsted, Conn.*

Belt Grinder: Automatic rotary abrasive belt grinder for OD grinding of ferrous and nonferrous metals, plastics, ceramics, glass and other materials, handles circular parts from 26 to 40 in. in diameter and can be modified to meet other diameter ranges. The wet or dry grinder has a self-contained, motor-driven work table which rotates at speeds of ¾ or 3 rpm. Optional change gears provide other speeds. Air-controlled infeed mechanism carries rotating parts in against the belt, and infeed travel is adjustable with minimum of 0.0016-in. per revolution. Parts are moved back and forth across belt face to insure even distribution of belt wear. Table is adjustable from 0 to 45 deg for angular grinding. Standard abrasive belt size is

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BMR—for heavy duty service with excessive misalignment

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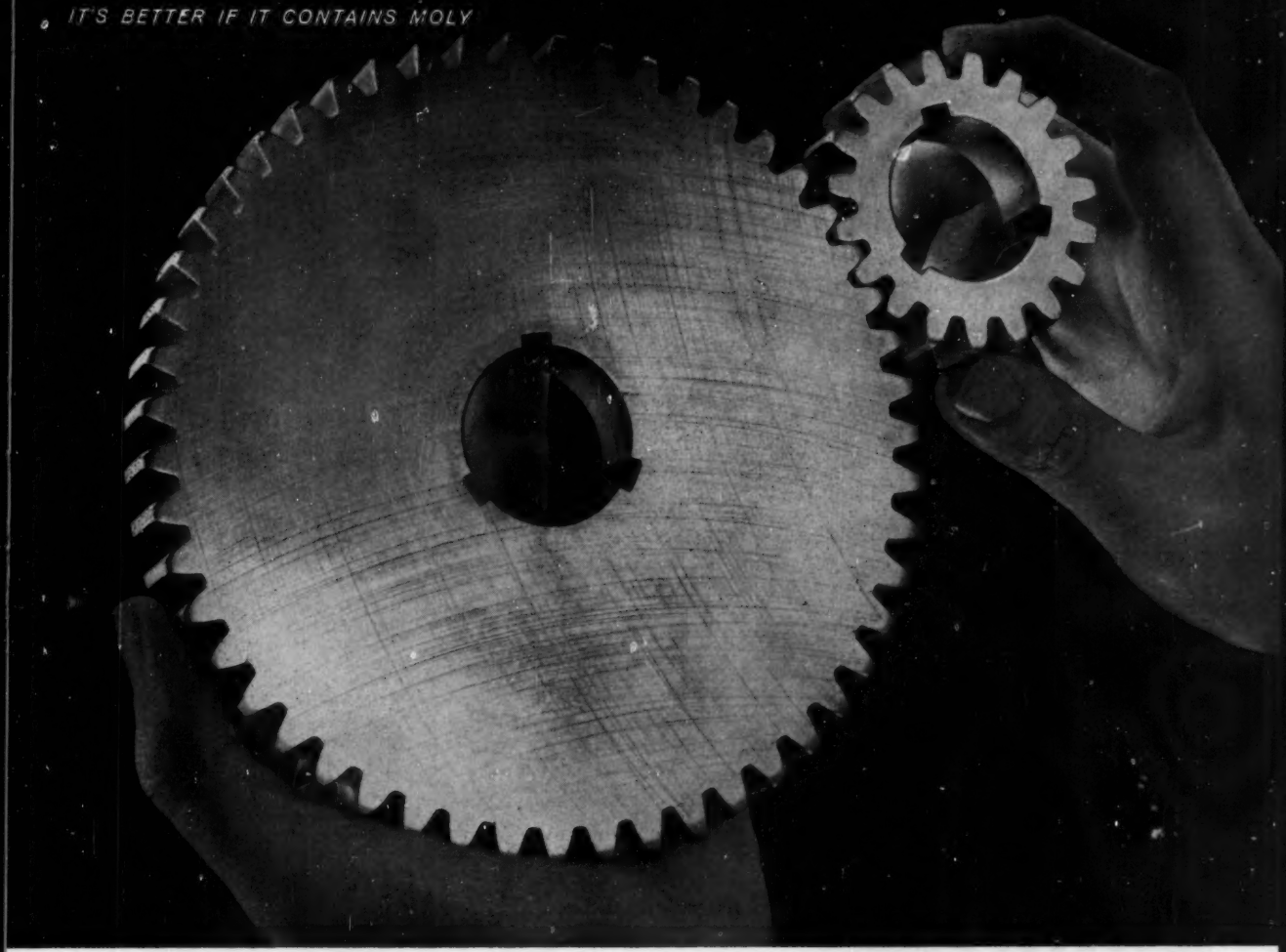
Circle 534 on page 19

IT'S BETTER IF IT CONTAINS MOLY



Up to 1% Moly in carburizing steels gives required hardenability economically

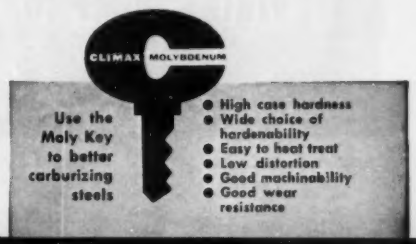
Why limit the use of molybdenum to the .15/.25% Mo and .20/.30% Mo contents of the traditional grades? For the contributions of moly do not stop there. Laboratory tests and production runs prove that as molybdenum contents increase up to 1%, hardness increases progressively. A wide range of case and core hardenabilities, therefore, can be obtained – economically, too.

Tests with a series of molybdenum-manganese steels show that these compositions give higher case hardness on a direct quench than other steels of comparable core hardenability. One extensively tested composition, for example, is 0.5% Mo – 0.5% Mn steel. It shows longer life, and is lower in cost than steels previously used. And it produces a higher case hardness with similar or less distortion. What's more, tool life and surface finish are equal or better. Good reasons why several companies have already adopted this grade for automotive gears and other critical applications.

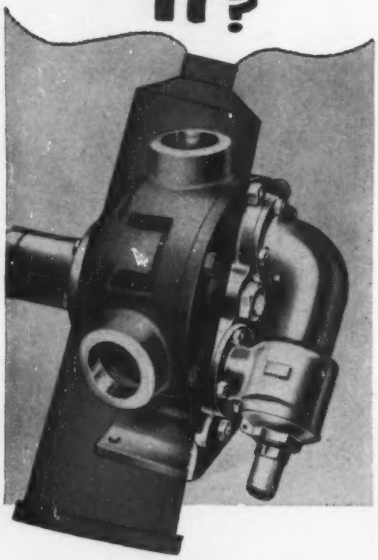
If you use carburizing steels, see what a higher molybdenum content can do for you. Part of the story is contained in the technical article "New Carburizing Steels For Critical Gearing." For your copy, or other technical data, write Climax Molybdenum Co., Dept. 11, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM

Circle 535 on page 19



HOW DO YOU HANDLE IT?



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Here's the answer to your problem of moving semi-solid materials of types usually dispensed in squeeze tubes. With Vikings you can pump such materials as tooth paste, shaving cream, petroleum jelly and many others, in a smooth-even flow. Hundreds of plants are doing it. Viking's simple, rugged "gear within a gear" principle makes it adaptable to most pumping needs. There are 750 catalogued models and thousands of specially built pumps and units. If you have a pumping problem, call on Viking Pumps for assistance. Ask for bulletin 57Sh.

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In Canada, it's "*ROTO-KING*" pumps
SEE OUR CATALOG IN SWEETS
Circle 536 on page 19

New Machines

8 x 107 in. with belt speed available from 2000 to 5000 sfpm. Capacity of coolant unit, equipped with ½-hp pump, is 100 gal. The unit is powered by a 10-hp motor. *Engelberg Huller Co., Syracuse, N. Y.*

Form and Punch Shaper: Jemco K-150 shaper for punch, die and contour forming produces high-precision, close-tolerance forms with round chamfer heads. Forms require no further machining operations. Worktable is adjustable in both directions. Length of stroke can be set from 0 to 6 in. Workpieces are clamped directly in a collet holder, between centers or to the co-ordinate chuck. Co-ordinate chuck and indexing attachment guides workpiece along the contour with one chucking. Machining operations can be checked in the shaping process with a built-in 30-power microscope. *Jersey Mfg. Co., Elizabeth, N. J.*

Gear Shavers: Improved Red Ring GCU 8 and 12-in. rotary gear shaving machines have new column design and built-in pushbutton electrical controls. Tunnels cast in the new column provide space for electrical controls and enable compact flush-mounting of the two pushbutton control panels in the top of the column within easy reach of operator. Separate cutter drive gear box is located in the top of the column. Model GCU 8-in. machine shaves spur or helical gears up to 4 diametral pitch having pitch diameters from 1 to 8 in. Model GCU 12-in. unit shaves spur or helical gears up to 4 diametral pitch with pitch diameters from 1 to 12 in. Both models are made in three types: A universal machine for conventional shaving of gears, including crowned and tapered types; a model which does not include crowning or taper shaving attachments; and a model which provides only for basic diagonal shaving with the two-stroke cycle. Cutter is driven by a 3-hp motor. *National Broach & Machine Co., Detroit.*

Lathe: New model No. 73 standard precision lathe is built with a hardened and ground bed, totally enclosed headstock of 1-in. collet capacity, and a 7-in. swing. Head-

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Circle 537 on page 19

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BRIGHTER THAN EVER!—MicroRold stainless steel Type 430 in the NEW Bright Finish is now immediately available in sheets up to 48" wide offering new usefulness and economy in stainless fabrication. Produced with the same micro-accuracy of gauge for which MicroRold 36" is well known, Type 430 Bright up to 48" wide gives greater latitude in applications for quality stainless steel.

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Circle 538 on page 19

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done better with UNITCASTINGS!

Faced with a problem of economically producing a starter housing that would take more than normal abuse, Unitcast engineers successfully provided the answer with *steel* castings. Previous to the use of Unitcastings, replacement costs were excessive and the need of a tougher material was imperative. Cost was also an important requisite, and by delivering *consistent* quality in conjunction with a tougher material—scrap and lost time has been held at a minimum. To date, more than 33,000 units have qualified with a higher basic cost being offset by practically no replacement and most important —a lower *finished* cost!

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UNITCAST CORPORATION, Toledo 9, Ohio

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New Machines

stock spindle is equipped with preloaded, antifriction, staggered cylindrical roller and ball bearings. Standard equipment includes draw-in bar, offset-type tailstock with hardened and ground full bearing spindle, hand rest, dog face plate, centers, center collet, compound slide rest, and micrometer dials graduated in thousandths of an inch. Totally enclosed adjustable speed drive provides an infinite range of spindle speeds from 100 to 3500 rpm. *Wade Tool Co., Waltham, Mass.*

Processing

Automatic Welders: Two new automatic welders are for carbon dioxide gas metal-arc or submerged arc dc welding. Each welder consists of a heavy-duty welding head, control, operator's remote control station, and interconnecting cables. Equipment provides uniform bead contour and crater elimination at high welding speeds. Inching of the wire, flux damping, and arc starting are performed automatically with Model SA-40A and manually with Model SA-40. Front-mounted dials permit quick and accurate setting for arc voltage and current. Controls are housed in a NEMA Type 12 dust-tight enclosure and conform to JIC standards. Welding head drives wire diameters from 5/64 to ¼-in. at speeds to 300 ipm. Head motor and gear train enclosures mount together to form a single cylindrical case mounted on a universal supporting frame. Two manual adjustments permit head to be rotated 360 deg in two planes. *Westinghouse Electric Corp., Pittsburgh.*

Vacuum Furnace: Model 437-520 precision casting furnace is designed primarily for fast-cycle production of precision components by either investment casting or permanent mold procedures by remelting high - purity vacuum or air-melted alloys. It will melt and pour single casts of 5 to 17 lb under vacuums as low as 2 microns. The unit can be modified to incorporate ridge-breakers, thermocouples, and provisions for adding alloying elements so that it can be used as a refining furnace.

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THIS IS SELF-ALIGNMENT. Spherical inner ring is free to align itself in any direction. Thus . . .
FULL LOAD CAPACITY is always assured, regardless of shaft deflection or misalignment.
Series 22200 and 22300 —22500-A and 22600-A roller bearings

Spherical LINK-BELT roller bearing compensates for shaft deflection, weaving of supports

MANY leading makers of tough duty equipment now design without bulky supports to prevent deflections. They're using this spherical Link-Belt roller bearing that *compensates for misalignment* . . . always keeps its full capacity for handling radial and thrust shock loads without "pinching."

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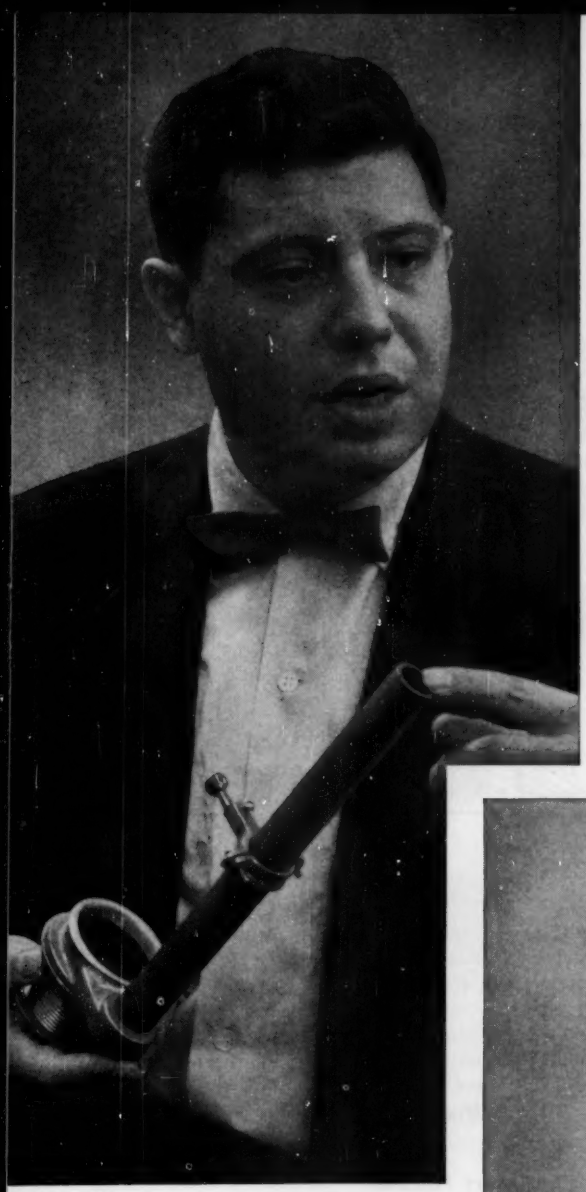
New Machines

Uniform, predetermined, repetitive melting and pouring cycles are readily obtained. Timer sounds an audible signal as the melt approaches correct temperature. Temperature at which to pour is determined by means of an optical pyrometer, sighting through a tube aimed at the center of the crucible in melting position. Cold slugs of feed stock can be inserted into the crucible immediately after pour has been completed and before vacuum is broken to conserve the residual heat in the crucible and prevent oxidation of the metal left in it. The furnace is available with 20, 30 or 50 kw induction heating units. *F. J. Stokes Corp., Vacuum Processing Equipment Div., Philadelphia.*

Resistor-Capping Machine: Automatic machine is designed for high-production capping of resistor bodies with press-fitted terminal caps. The unit can be tooled for a variety of resistor bodies ranging from 1/16 to 5/16-in. in diameter. Vibratory hopper feeds automatically maintain full chutes for uninterrupted operation. Caps are fed at 100 per minute and 3000 resistors are assembled per hour. *Halm Instrument Co. Inc., Special Products Div., Glen Head, N. Y.*

Vinyl Form Machine: Fay Foamer permits the continuous manufacture of vinyl foam at low pressures with maximum uniformity and efficiency at density of 5 lb or more per cu ft. Liquid vinyl plastisol is automatically charged into the equipment which permits carbon dioxide to be absorbed in controlled amount. Vinyl foam is discharged as a stable cream which can be injected into molds or extruded onto a conveyor, and is then fused at 300-340 deg. *Dennis Chemical Co., St. Louis.*

Hydraulic Marking Machine: No. 710 marker performs normal marking operations requiring up to 8000 lb pressure with a maximum lettering length of 3½ in. It stamps up to four lines of 1/16-in. characters. Unit has a heavy die slide which operates on roller bearings. Machine accepts flats up to 5 in. thick and rounds to 5 in. diameter. *Parker Stamp Works, Hartford, Conn.*



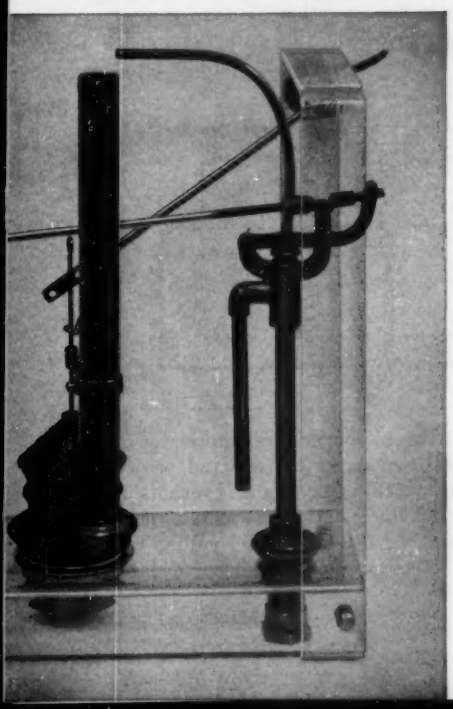
Consulting engineer Hilton Atlas talks plastics:

"Brass, in recent years, has undergone wild price fluctuations resulting in continually higher costs. As a stockpiled commodity, there was always the question of its being obtained in time to meet production deadlines, and only by cutting down the wall thickness of water closet overflow tubes could the metal remain economically feasible," states Mr. Atlas, Technical Director, Hancock Manufacturing, Inc., Philadelphia. "It reached a point where tube walls resembled foil, and pressure or a bump either ruined the threads or put them out of round. Research led us to DYLENE® polystyrene.

"Using DYLENE, we produce, at a lower cost, a superior product possessing strength, durability, fine corrosion-resistant properties and the ability to withstand constant handling from manufacture to installation. It's used exclusively for the 350,000 overflow tubes we turn out annually.

"Some time ago we discovered that DYLENE possesses excellent ability to respond to quality controls, has dimensional stability, extrudes easily, maintains tolerances and has wide color possibilities. Coloring was important. We felt that in replacement of brass it would not be advisable to go too far afield by changing radically the 'accepted' color. These factors reduced resistance to the new material.

Threaded DYLENE overflow tube



◀ Full assembly

"Our aim is to gradually replace *all* metal parts used inside toilet tanks—hush tubes, flush valves, ball cocks, rods and tubes—with suitable plastics. Our most recent step has been the replacement of copper floats with DYLITE® expandable polystyrene. We use DYLITE because of its strong, tough skin and controllable density. It resists fungi and has low water absorption. Important, too, is an 87% weight saving that stacks up to appreciable freight savings."

Today's plastics are saving weight, reducing manufacturing costs and improving products in hundreds of fields. Have you investigated the possibilities of plastics in *your* product? We'd be glad to go over the problem with you. In addition to DYLENE and DYLITE, Koppers manufactures two other plastics. They are DYLAN® polyethylene and SUPER DYLAN* polyethylene. For more information on any of these plastics, write to Koppers Company, Inc., Chemical Division, Room MD-17, Pittsburgh 19, Pennsylvania.

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Circle 541 on page 19

Do you have the facts on Linear's new, exclusive ROTO-MOLD process? It brings *automation* to the packing industry—makes possible fast delivery of perfectly uniform "O" Rings in any quantity!

★ Linear ROTO-MOLD "O" Rings are made with laboratory precision in single cavity molds under individually controlled pressure. Molding dies are automatically brought into microscopic alignment.

★ Every ROTO-MOLD "O" Ring is perfectly circular in cross section, with no transverse or other seams. You get precise uniformity without trimming or grinding.

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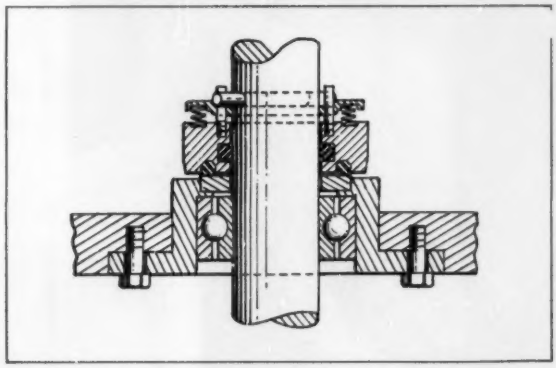
Self-Cleaning Face Seal

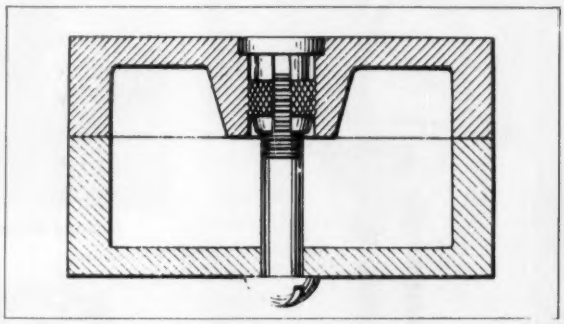
Effective blockage of fluid leakage between a rotating shaft and housing, even under conditions of misalignment, is provided by a self-cleaning face seal. Self-cleaning feature is due to the rotational sweeping



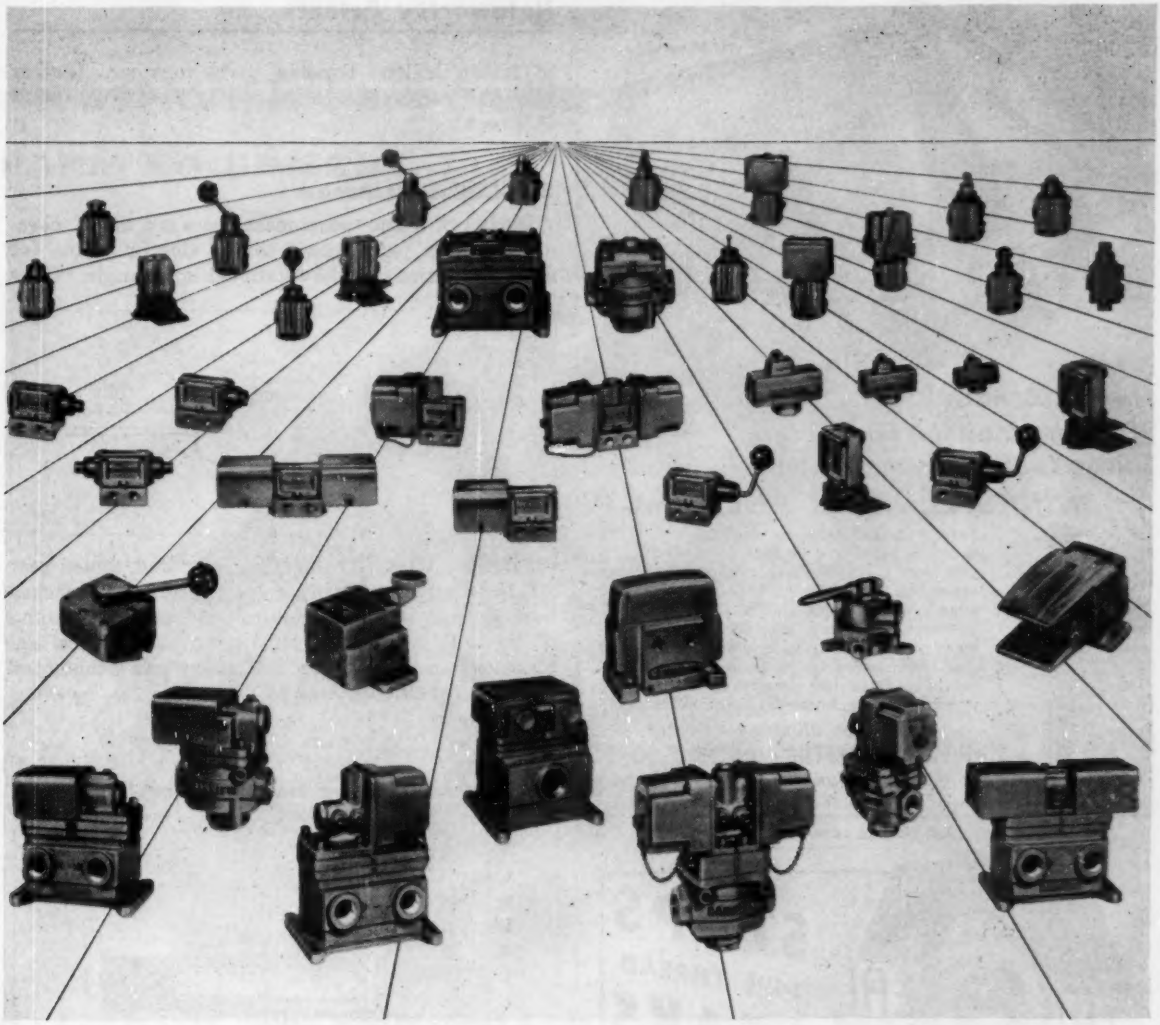
action of an O-ring sealing element, which is mounted in a variable-radius (elliptical) rather than an axially concentric (circular) groove. Use of the flexible O-ring element for sealing eliminates need for conventional precision-lapped surfaces and allows application of the unit where low cost is a factor. *Patent 2,768,011 assigned to Federal-Mogul-Bower Bearings Inc. by Ezra D. Mosher.*

Expansion Insert Fastener

Designed to allow initial insertion by hand-pressure only, an internally threaded, split-tube, expansion insert locks in the mounting hole with minimum ex-



pansion and offers high torque resistance to the engaging screw. Knurled outer surface and projecting upper shoulder, which is not split, prevents insert from pulling out of plastics or metals under heavy loads or loosening by the "wheel-pulling" action of the screw. Sketch illustrates use of insert



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Discriminating engineers are finding that out. More and more of them are specifying Hannifin valves for every kind of directional air control—including the really tough jobs.

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AIR CONTROL

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VALVES

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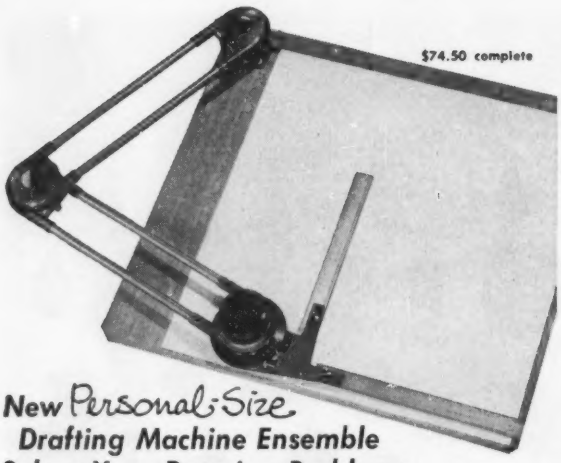

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TEFLON SEAL

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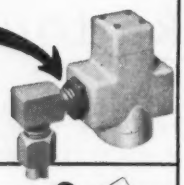
STOPS PIPE THREAD LEAKS



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$10.00 Trial Offer No. 1: six ⅛", ten ¼", six ⅜", eight ½" pipe thread TRU-O-SEAL Fittings.

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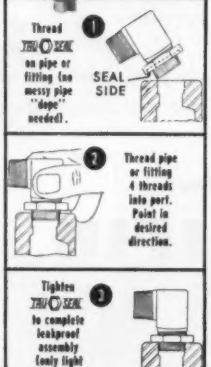
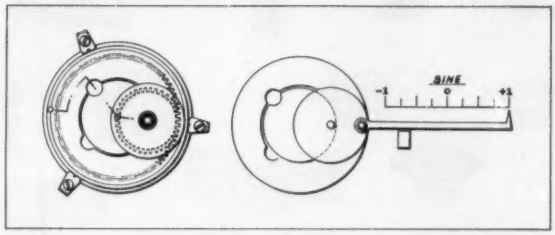

1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

Noteworthy Patents

to fasten hollow, box-like parts together. *Patent 2,765,697 assigned to Norman Jay Boots by Abbott H. Brush.*

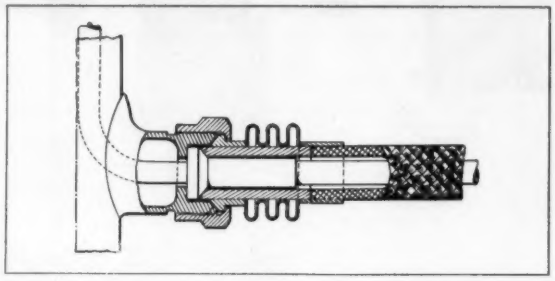
Sine-Cosine Mechanism

Output of a sine-cosine mechanism is a linear movement that is proportional to the sine or cosine (or similar function) of the rotational input angle. Com-



prising an internally meshing ring and pinion-gear set, the mechanism incorporates a rotatable pin-locked base plate to permit convenient and accurate zeroing of the unit in any of several positions. Typical applications include analog computers and simulators. *Patent 2,754,687 assigned to Librascope Inc. by Chester Brandon.*

Length-Compensating Electrical Coupling



For high-voltage harness applications, such as in shielded ignition systems, a length-compensating conduit coupling employs a flexible bellows as a means of altering the effective length of the conduit. Unit facilitates installation and removal of cut-to-length shielded cables without danger to the watertight integrity of the assembly. *Patent 2,768,010 assigned to Breeze Corp. Inc. by Stanley P. Bird.*

Motion transmission at constant velocity ratio with minimum tooth interference is provided by a unique gear configuration wherein gear teeth extend in an axial direction from the gear side faces. Intended for application where small face width is desirable, such as high-reduction drives, the gears employ circular-arc tooth working faces cut by a rotary cutter. Configuration is particularly advantageous when applied to gear sets that mesh internally since tooth-profile curvature is small enough to permit use of large diameter cutters for fabrication. *Patent 2,750,-814 assigned to Gleason Works by Ernest Wildhaber.*

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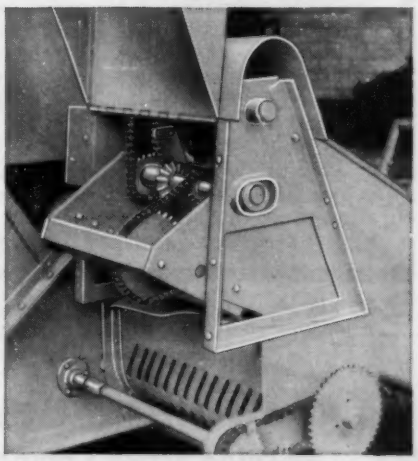
Tests show that the Case "201" saves nearly 99% of the cotton it strips. Efficiency such as this results from excellent design and manufacture—and the selection of efficient, long-life DIAMOND Roller Chain Drives shown at the right.

These DIAMOND Roller Chain Drives are as positive as gears, efficient, light weight, flexible for better placement of shafts, easy to maintain and they deliver non-slip power throughout their entire life. Look for the Diamond on the link plates.



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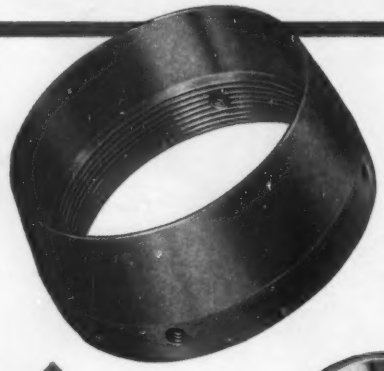
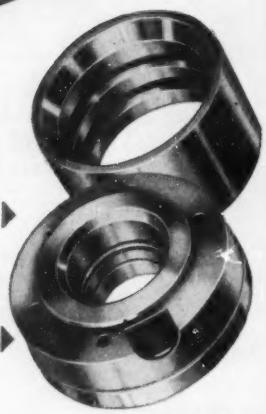


This 4½" round alloy steel part has No. 12 pitch, class 3 fit internal threads, and requires 20 separate operations including pentrating and magnafluxing.



This 3¾" alloy steel part is hardened and ground. Tolerance of o.d. is just .0005".

This 4⅛" round part requires drilling, counterboring and recessing.

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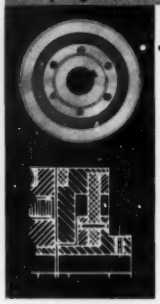

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The higher the pressure the tighter the seal

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¼" SIZE

MODEL BVP1—Single Solenoid less exhaust controls.

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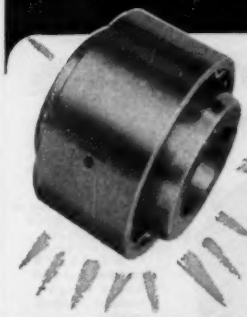

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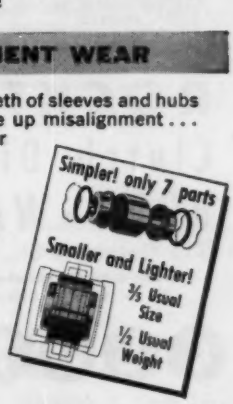

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CLUTCH LIFE
TORQUE CAPACITY
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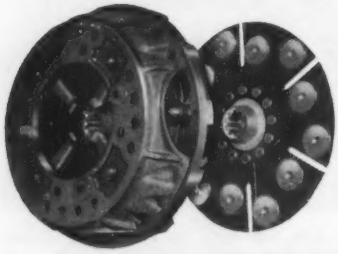

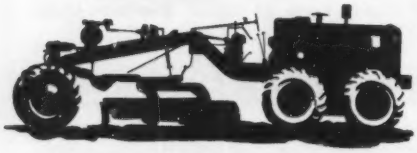

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Designed especially for use in heavy-duty, high-speed engine equipped machines such as trucks, tractors, earth movers, graders, shovels, cranes, dozers and oil field units—

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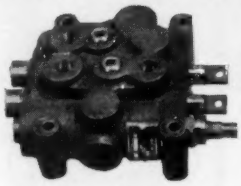
HUSCO HYDRAULIC CONTROL VALVES



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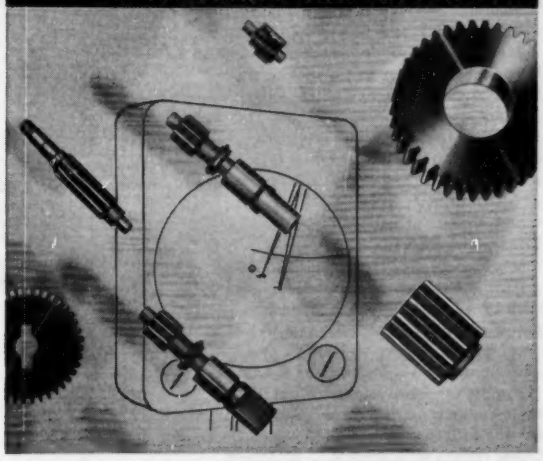

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Vacuums to 27" Hg.
Pressures to 20 psig.
Displacement:
3.6 to 7.2 c.f.m.

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Integral Rotary
AIR PUMP
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MODEL K. 3.6 c.f.m. ½ hp.
13½" long - - 12" wide - - 7" high

MODEL K3. 7.2 c.f.m. ½ hp.
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- Steel wings for long wear
- Automatic Wing Adjuster
- Automatic oiler—requires filling only once in 60 to 80 hours.
- Ball bearings for quiet running
- Bearing grease cups need checking only once in 90 days
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- Automatic thermal overload motor protection
- Noiseless operation
- Inlet filter and outlet separator
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Patented Leiman feature adjusts automatically, pushes steel wings into contact with cylinder wall, assures constant seal, prevents wings from sticking or binding.

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Circle 558 on page 19

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Circle 557 on page 19

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we'll show you how you can save up to 70%

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(*Very High Sensitivity)

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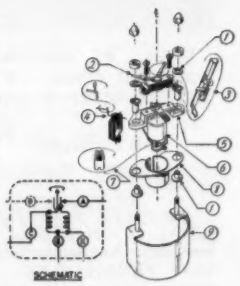
Model 266

Sample specs. are: 0.2 micro-amperes, (12,000 ohms coil) or, 0.1 millivolts, (5 ohms.)



1. Shock mount
2. Contact assemby
3. Contact detail
4. Armature with contact detail
5. Cast bracket
6. Alnico magnet
7. Bearing detail
8. Yoke (steel)
9. Mounting frame

Cleveland Electronics Show, Feb. 16-17, Masonic Auditorium

Circle 560 on page 19

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Circle 561 on page 19

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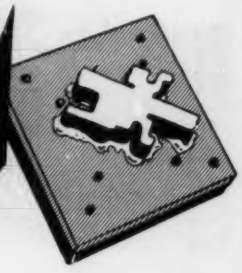

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Circle 562 on page 19

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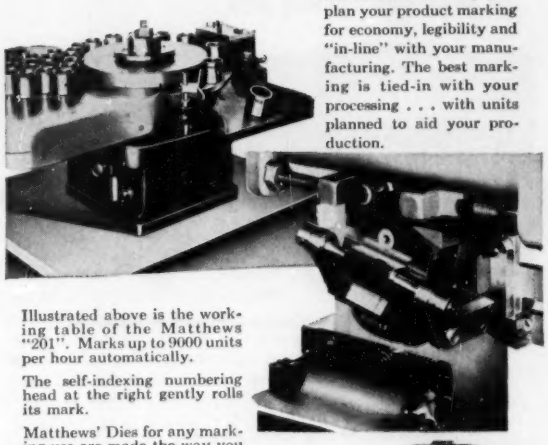

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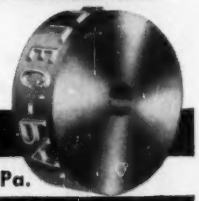

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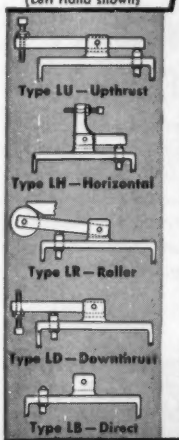

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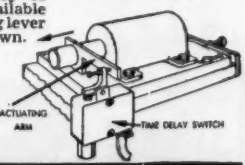

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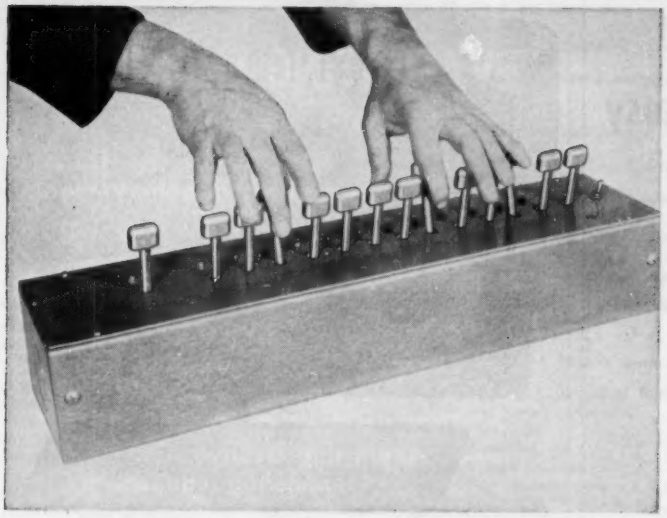

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Circle 568 on page 19

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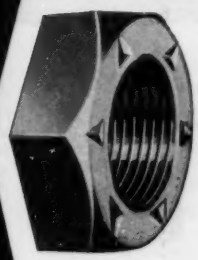

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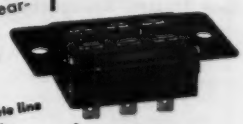

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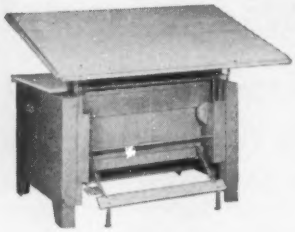

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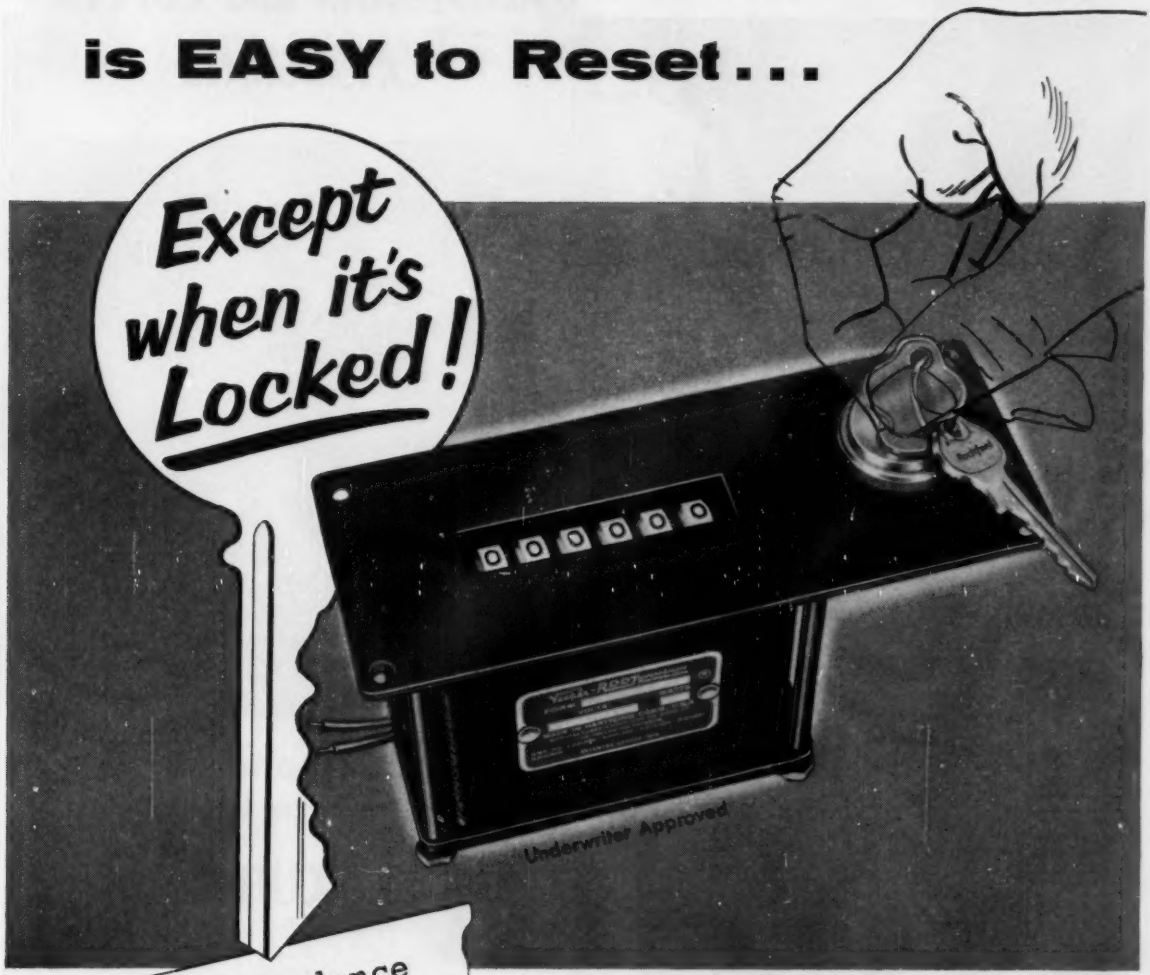
This NEW Magnetic Counter is EASY to Reset...



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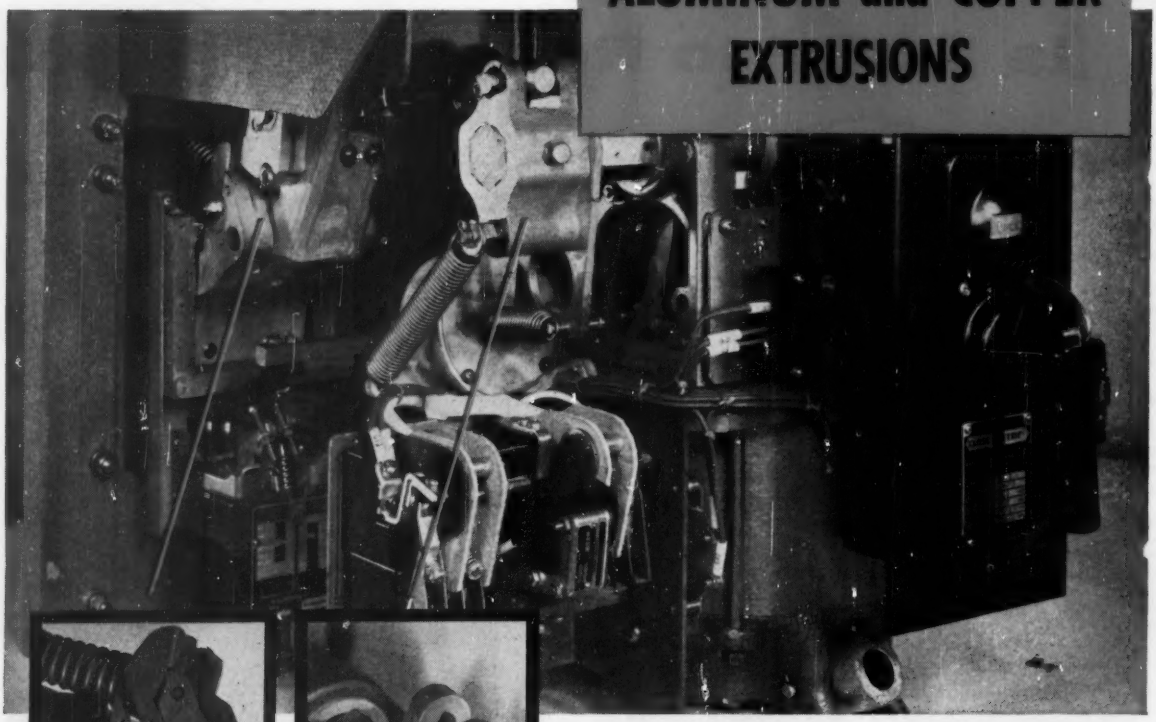
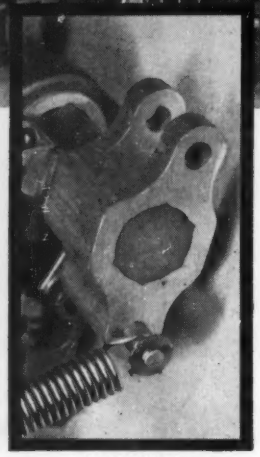


COPPER
for conductivity



ALUMINUM
for economy

—form a Money-Saving team in latest

I-T-E CIRCUIT BREAKERS

Revere T. A. Service an Important Factor in Ultimate Design of Parts

The larger of the two extruded and drawn copper shapes shown at extreme left started out on the drawing board as two pieces. It was thought that a single shape of this size could not be made satisfactorily. At this point, I-T-E Engineers got together with Revere's T. A. (Technical Advisory) Service and threshed things over. The final result is the one-piece extrusion shown and a reduction in machining time.

Aluminum was selected for the other extrusion shown because I-T-E found that it cost less per pound of metal and had a higher strength ratio when compared to a casting. Also, space was a factor. In all, Revere supplies 5 copper and 2 aluminum extrusions for KD and KE type I-T-E Circuit Breakers. All were designed to fit specific requirements of I-T-E Engineers. Where it could be used satisfactorily, aluminum was applied because of economy, while current carrying members called for copper.

This is still another example of Revere supplying the metal that will do the best job and with the greatest economy . . . be it aluminum, copper or any one of their alloys. So, with new things happening all the time in non-ferrous metals it can pay you to keep in close touch with Revere.

COPPER ★ BRASS ★ 18 01 ★ REVERE ★ ALUMINUM

REVERE COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

This new Guide to Gear Lubrication saves time, money and headaches

FARVAL—
Studies in Centralized Lubrication
No. 195

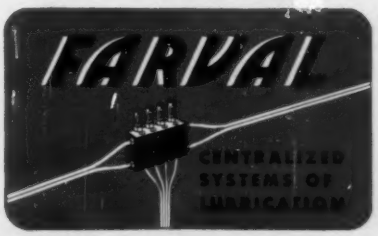
● If you design, build or use equipment with large gears, you will want Bulletin 60-A. Its 8 pages provide full information on Farval Spray Lubrication Systems available for manual or automatic operation.

Farval Spray Valves are completely flexible. They can be used alone, in panel set-ups mounted on gear housings, or as part of a Farval Dualine System—wherever compressed air is available. As with standard Dualine valves, the spray can be operated as often as needed to deliver any amount of oil or grease—on gears, slide surfaces or other areas needing lubrication.

Thousands of Farval Spray Valves are used in many industries. You, too, should enjoy their benefits. Write today. You will receive a copy of Bulletin 60-A and the name of the Farval representative in your area who can help you select the proper equipment for your machines. The Farval Corporation, 3287 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing.
In Canada: Peacock Brothers Limited.

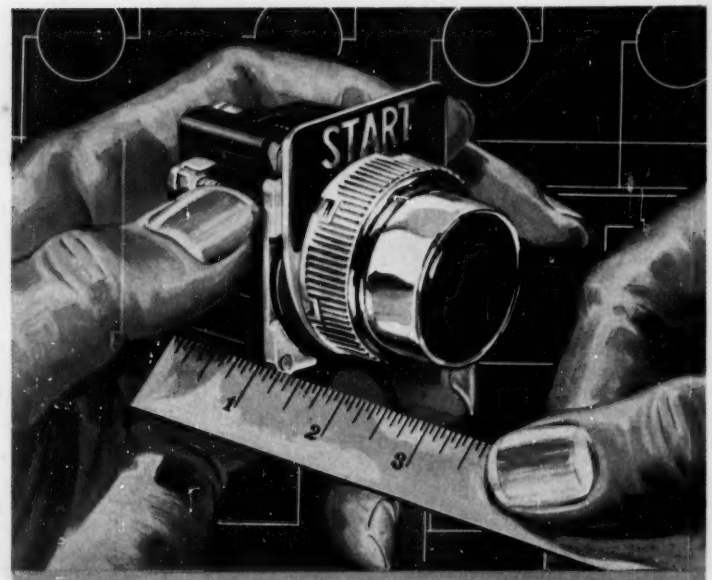
Proved in 30 years of service, Farval manual and automatic centralized lubrication systems protect millions of industrial bearings. Wherever you see the familiar Dualine valve manifolds, dual lubricant lines and central pumping station, you know a machine is being properly lubricated.



Circle 402 on page 19

☆ ☆ ☆

Machine designers say these new heavy duty pushbutton units have no equal and prove it by adopting them as standard equipment



These are the world's smallest heavy duty pushbuttons. They require a behind-the-panel depth of only 1 3/32". This is 40% less space than needed by the next smallest units on the market. Double-pole contact blocks are available in all combinations of normally open and normally closed contacts. Each control circuit is electrically and mechanically isolated from the other. Each circuit is clearly identified and all terminals are color coded. Rapid on-the-job circuit additions are obtained by stacking contact block on contact block.

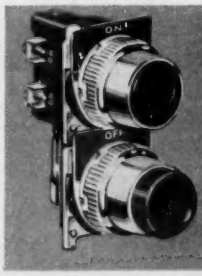
☆ *they install easier*

☆ *they work better*

☆ *they last longer*

Design engineers are quick to recognize that these new heavy duty pushbuttons have *everything*. There is nothing on the market like them. They are amazingly compact to require the least back-of-panel depth. They are one-hole mounting and they are oil tight. They easily provide for as many as eight separate control circuits per pushbutton, eight completely isolated heavy duty contacts either normally open or normally closed. The buttons may be flush type, the extended type or with mushroom heads. They can be black, red, yellow, green or gray. See the new one-button control station, C-H Roto-Push. See the easiest-to-install maintained-contact pushbutton attachment and the means for padlocking any of the standard pushbuttons. There are both knob and key operated selector switches in this complete line. Also matching indicating lights and the new automation safety light, PresTest. Be sure you have complete information *now*. Write today on your company letterhead for a copy of the new Cutler-Hammer Panel Builders Handbook Pub. EE-120. CUTLER-HAMMER, Inc., 1310 St. Paul Ave., Milwaukee 1, Wisconsin.

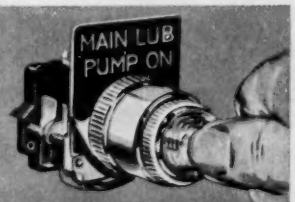
These pushbuttons may be flush type, extended type or with mushroom heads . . . in a wide range of colors for quick control identification. Standard, large, and jumbo size legend plates fit every type of operator and indicating light in the entire line.



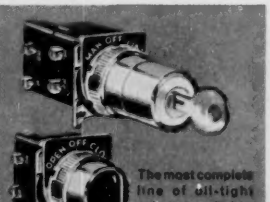
A maintained-contact pushbutton assembly that saves more than its entire cost by installation savings. New attachment with its pushbuttons mount in minutes; no fussy adjustments. Neither alignment nor spacing of units is critical. Pushbuttons will not bind or stick; always operate perfectly.

CUTLER-HAMMER
☆ ☆ ☆
MOTOR CONTROL
C-H

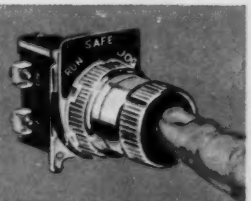
The C-H one-hole mounting oil-tight indicating lights with new wide-visibility lenses are the most visible from all angles by actual light meter tests. Available in either transformer or resistor types. Lenses offered in six different colors.



PresTest . . . the self-testing indicating light. Vital to safety and proper use of machines, particularly in automation. PresTest now permits instant proof light is NOT off because of burned-out bulb. Merely pressing on the light lens disconnects bulb from its normal circuit and checks it on a test power supply. Resistor and transformer types available.



The most complete line of oil-tight selector switches on the market. Key or knob operated; two or three position. Positions may maintain contact or have spring return. Three standard contact blocks provide a wide range of circuit combinations with the use of just a single block. Unlimited circuitry by adding blocks.



Roto-Push . . . the one-button control station. One Roto-Push can provide all the control functions for which two or three separate pushbuttons would be used normally. Available in a wide range of selector and button operators, Roto-Push simplifies panel design and saves installation time to cut costs, improves machine-operator efficiency.

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